AGRICULTURAL DRAINAGE CONTRIBUTION TO WATER QUALITY IN THE GRASSLAND AREA OF WESTERN MERCED COUNTY, CALIFORNIA: October 1988 through September 1989

WATER YEAR 1989

California Regional Water Quality Control Board
Central Valley Region
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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

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SUMMARY

In May 1985, Regional Board staff began a water quality monitoring program to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland Area of western Merced County. The purpose of this monitoring program was to compile an on-going database for selected inorganic constituents found in the agricultural drains discharging to and flowing through the Grassland Area. This database will be used in the development and evaluation of future agricultural drainage reduction programs in the San Joaquin River Basin. A report on this water quality survey has already been prepared and approved by the Board for May 1985 through September 1988. The current report covers October 1988 through September 1989, a time period which encompasses the critically-dry Water Year (WY) 1989, and provides a long-term data base for assessing the effects of future regulatory actions.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tailwater) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals which can divert water in a number of possible ways before it reaches Mud Slough (north) and/or Salt Slough and ultimately the San Joaquin River. A water quality monitoring network was established to ensure measurement of inflows to the Grassland Area, internal flows within the Grassland, and outflows to the San Joaquin River.

The current study shows that water quality continues to vary widely with the highest constituent concentrations found at the inflow monitoring stations near the southern boundary of the study area. This inflow water is generally a blend of subsurface tile drainage and surface runoff (tailwater) or operational spills from irrigation canals. Four of these inflow points carry a substantial portion of subsurface drainage water. The highest concentrations at these four sites likely reflect a greater proportion of tile drainage in the flow and not necessarily the quality of subsurface drainage being discharged at the tile drainage sumps. The sites inflowing from the south and southeast continue to carry the highest concentrations of salts, boron, and selenium. Other inflows contain little selenium; however, elevated levels of salt and boron are present. For example, the median values for selenium at the four major southern inflow points ranged from 49 to 95 μg/L while other southern inflow points showed selenium values ranging from 2.9 to 6.7 μg/L. For boron, however, the four drains carrying the high selenium water showed median boron values ranging from 3.8 to 6.5 mg/L while the other southern inflow drains that have lower selenium values showed median boron values ranging from 2.2 to 7.6 mg/L. The two inflows which primarily contain drainage from Sierra Nevada deposits as well as fresh supply water continue to show the lowest median selenium concentrations at 1.0 and 1.2 μg/L, respectively.

Concentrations at the internal flow and outflow monitoring stations were comparable to each other and were substantially lower than the southern inflows. The water quality reflects the amount of mixing and dilution that takes place as drainage water moves through the Grassland Area. The flows are strongly regulated by an extensive system of man-made structures and trends in water quality are difficult to identify.

The two main outflows, Mud Slough (north) and Salt Slough were monitored during the study. These sites represent water quality of the blended drainage flowing from the Grassland Area to the San Joaquin River. The quality of both sloughs varied widely depending upon which slough was carrying the greatest portion of subsurface tile drainage water. During WY 89, Salt Slough appeared to carry the highest proportion of tile drainage based on elevated trace element concentrations. For example, Salt Slough selenium concentrations ranged from 2.7 to 38 μg/L with a median of 15 μg/L. Mud Slough showed a similar variability with a median selenium value of 2.1 μg/L. Concentrations for all the drains and sloughs were routinely higher during the critical Water Years 1987-89 than they were during the wet Water Year 1986. Seasonal variations in constituent concentrations occurred in Water Year 1989 in a manner similar to the previous three Water Years, with the highest levels occurring during the nonirrigation season (October to March).

RECOMMENDATIONS

1. In cooperation with other agencies and dischargers, continue water quality monitoring at the inflow points to the Grassland Area in order to expand the database needed to evaluate the effectiveness of the drainage reduction programs being developed for the Western San Joaquin Valley;

2. Reduce or eliminate the internal flow stations within the Grassland Area as operation and management play a major role in their water quality;

3. In cooperation with other agencies, ensure continued water quality and flow monitoring at the two main outflow stations (Mud Slough (north) and Salt Slough) to the San Joaquin River;

4. Have continuous flow monitoring equipment installed on the four main inflow drains to the South Grassland Area which are not presently gauged to aid evaluation of future agricultural drainage reduction programs in the San Joaquin River Basin.

INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program in May 1985 to evaluate the effects of subsurface agricultural drainage on the water quality of the drains in the Grassland Area in western Merced County. The study area is west of the San Joaquin River between Newman and Oro Loma, California (Figure 1). The purpose of this monitoring program was to compile an on-going database for selected inorganic constituents found in the agricultural drains discharging to and flowing through the Grassland Area. This database will be used in the development and evaluation of an agricultural drainage reduction program in the San Joaquin River Basin. This report contains laboratory results and a brief summary of the water quality analysis for samples collected from October 1988 through September 1989. Two previous reports (James et al., 1988, and Chilcott et al., 1989) present data for the period May 1985 through September 1988. This report is a discussion of the entire Water Year (WY) 89 which extends from 1 October 1988 through 30 September 1989.

STUDY AREA

The Grassland Area is comprised of the Northern and Southern Divisions of the Grassland Water District and the farmlands adjacent to the District (Figure 1). Land in this area is primarily used for agriculture and seasonal wetlands for wildlife.

Agricultural lands east, west, and south of the Grassland Area discharge subsurface agricultural drainage water (tile drainage) and surface runoff (irrigation tailwater) to the Grassland Area. This drainage often contains high concentrations of salts, selenium, and other trace elements. This regional drainage flows north through the Grassland Area where it is carried by a network of canals which can divert water in a number of possible ways before it reaches Mud Slough (north) and/or Salt Slough and ultimately the San Joaquin River.

There were 32 stations in the Grassland monitoring program as described by James and others (1988). They were divided into three categories: inflows to, internal flows within, and outflows from the Grasslands Area. Inflow monitoring stations were located on drains that discharge into the Grassland area and are mainly located at the southern end of the study area. Monitoring stations on the internal flow canals were located on drains within the Grassland Area that carry or could carry subsurface tile drainage as it passes through the area before discharging to the San Joaquin River. Outflow monitoring stations were located where drains or natural waterways flow out of the Grassland Area. Many of the internal flow stations described by James and others (1988), have been dropped from the monitoring program due to the large effect management plays in their water quality. The present report concentrates on the inflow and outflow stations. A list of the monitoring stations is shown in Table 1. Stations which have continuous data from May 1985 through September 1989 have been highlighted. The remaining stations, except for three outflow monitoring points, were dropped from the monitoring program by February 1988 with the corresponding data reported in James and others (1988) and Chilcott and others (1989). In this study, there are 11 inflow, 2 internal flow, and 4 outflow monitoring stations. The two internal flow stations are maintained to assess the approximate concentration of selenium in the two main fresh water supply source canals to the Grassland Area. Table 1 also identifies the map index number for each site as shown on the location map in Figure 2.

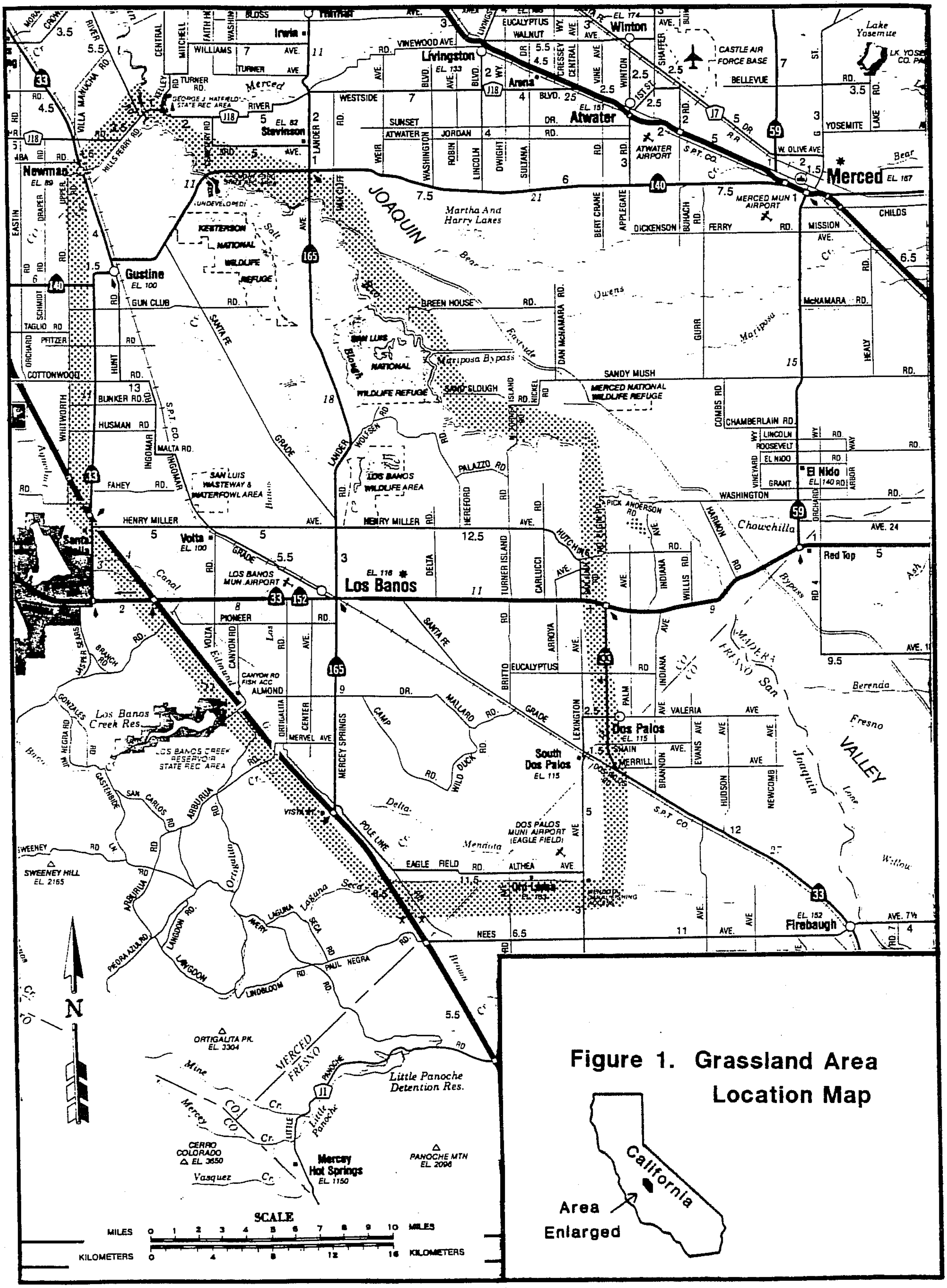


Figure 1. Grassland Area Location Map

Table 1. Water Quality Monitoring Sites in the Grassland Area (adapted from James et al., 1988 and Chilcott et al., 1989).

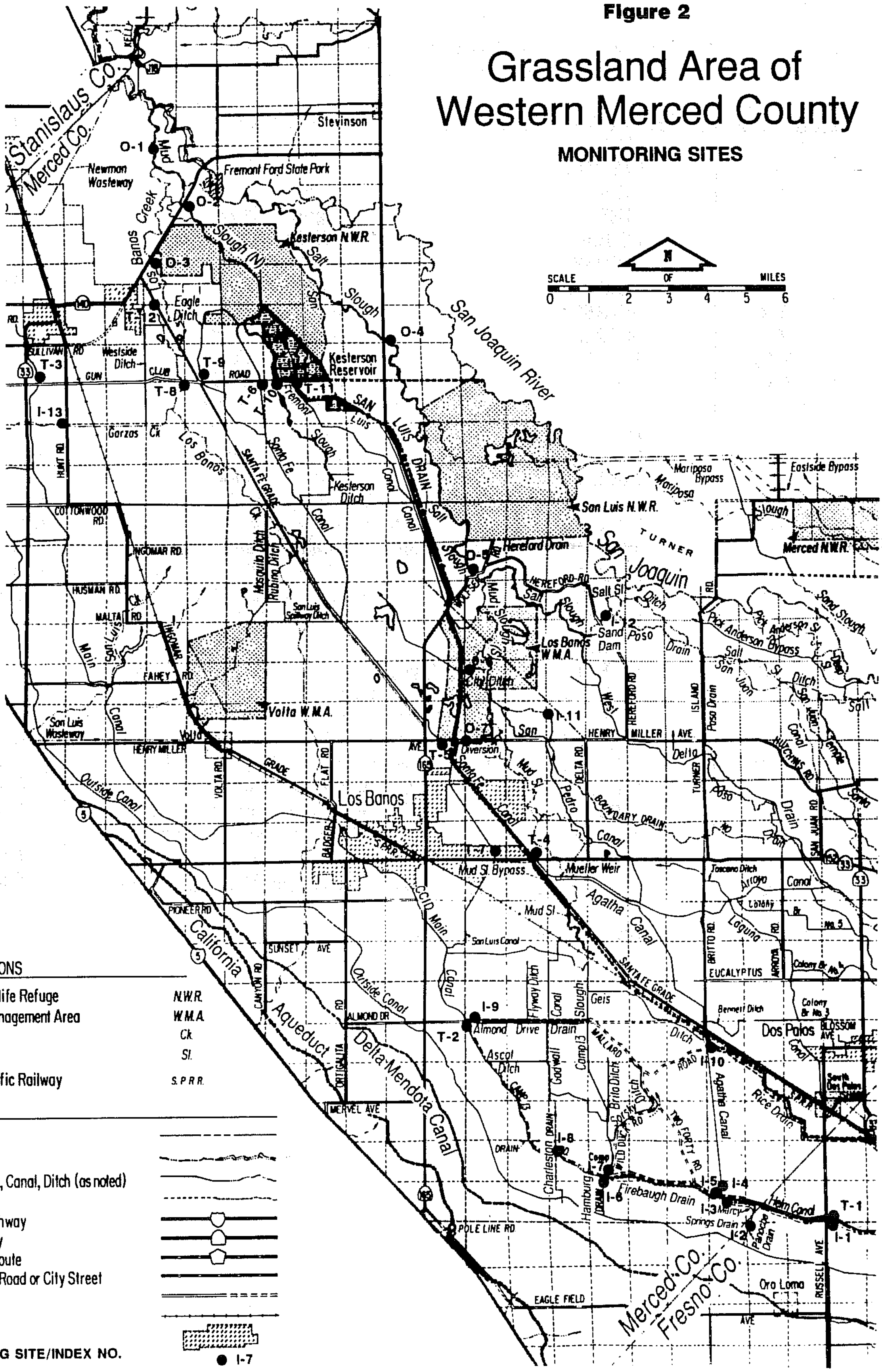
Map Index	RWQCB Site I.D.	Site Name	Site Type
I-1	**MER556**	**Main (Firebaugh) Drain @ Russell**	**Inflow**
I-2	**MER501**	**Panoche Drain**	**Inflow**
I-3	**MER552**	**Agatha Inlet (Mercy Springs) Drain**	**Inflow**
I-4	**MER506**	**Agatha Canal**	**Inflow**
I-5	MER507	Helm Canal	Inflow
I-6	**MER504**	**Hamburg Drain**	**Inflow**
I-7	**MER505**	**Camp 13 Slough**	**Inflow**
I-8	**MER502**	**Charleston Drain**	**Inflow**
I-9	**MER555**	**Almond Drive Drain**	**Inflow**
I-10	**MER509**	**Rice Drain**	**Inflow**
I-11	**MER521**	**Boundary Drain**	**Inflow**
I-12	**MER528**	**Salt Slough Ditch @ Hereford Road**	**Inflow**
I-13	MER513	Garzas Creek @ Hunt Road	Inflow
T-1	**MER510**	**CCID Main @ Russell Avenue**	**Internal Flow**
T-2	MER511	CCID Main @ Almond Drive	Internal Flow
T-3	MER512	CCID Main @ Gun Club Road	Internal Flow
T-4	MER540	Santa Fe Canal @ HWY 152	Internal Flow
T-5	MER519	Santa Fe Canal @ Henry Miller Rd.	Internal Flow
T-6	MER517	Santa Fe Canal @ Gun Club Rd.	Internal Flow
T-7	**MER527**	**San Luis Canal @ HWY 152**	**Internal Flow**
T-8	MER514	Los Banos Creek @ Gun Club Rd.	Internal Flow
T-9	MER518	Eagle Ditch	Internal Flow
T-10	MER516	Mud Slough (North) @ Gun Club Rd.	Internal Flow
T-11	MER515	Freemont Canal @ Gun Club Rd.	Internal Flow
T-12	MER553	Gustine Sewage Treatment Plant Ditch	Internal Flow
O-1	**MER551**	**Mud Slough (N) @ Newman Gun Club**	**Outflow**
O-2	**MER541**	**Mud Slough (N) @ HWY 140**	**Outflow**
O-3	**MER554**	**Los Banos Creek @ HWY 140**	**Outflow**
O-4	**MER531**	**Salt Slough @ Lander Avenue**	**Outflow**
O-5	MER530	Salt Slough @ Wolfsen Road	Outflow
O-6	MER543	City Ditch	Outflow
O-7	MER548	Santa Fe Canal-Mud Slough Diversion	Outflow

Bold print indicates that site has data for WY 89

Figure 2

Grassland Area of Western Merced County

MONITORING SITES



METHODS

The frequency of sample collection for this phase of the monitoring program varied, but generally grab samples were collected during the first week of each month and were analyzed for total recoverable selenium, boron, chloride, sulfate, total alkalinity, and electrical conductivity (EC). Because of the continued drought conditions throughout WY 89, more frequent sampling was conducted at outflow sites O-2 and O-4 (Table 1). Selected inflow and outflow monitoring sites were also sampled for total recoverable copper, chromium, lead, molybdenum, nickel, and zinc. Water temperature, pH, EC, and sample time were recorded in the field for each site. All samples were collected in polyethylene bottles. All the selenium and trace element sample bottles were washed and acid rinsed in the laboratory prior to use. All sample bottles were rinsed three times with the water to be sampled prior to sample collection. Selenium and trace element samples were preserved by lowering the pH to less than 2 using ultra-pure nitric acid fixation techniques. All samples were kept on ice until preservation or submittal to the laboratory.

A quality control and quality assurance program was conducted utilizing spike and duplicate samples in the laboratory. In addition, blind replicate samples were collected at 10 percent of the sites and 50 percent of the blind replicates were spiked for laboratory quality assurance. Reported results fall within quality assurance tolerance guidelines outlined in Regional Board laboratory quality control files.

RESULTS

Following the trend described in James and others (1988) and Chilcott and others (1989), the highest concentrations of the measured constituents were found at the inflow monitoring stations near the southern boundary of the study area. Concentrations at the internal flow and outflow monitoring stations were comparable to each other and were substantially lower than the southern inflows. Water quality analysis results at the inflow, internal flow, and outflow monitoring stations will be discussed separately.

Water quality results for both minerals and trace elements are listed by site in Appendices A through C; Grassland inflows (Appendix A), internal flows (Appendix B), and outflows (Appendix C). The range and median values for each measured constituent at each site are also shown in these appendices. For this study, electrical conductivity (EC), boron, chloride, and sulfate were the primary mineral constituents of concern. Selenium and molybdenum were the primary trace elements of concern. The median mineral and trace element values at each inflow monitoring station are listed in Table 2 for WY 89 (October 1988 through September 1989).

Minerals

Inflow Monitoring Stations:

The inflow monitoring stations represent the quality of the agricultural drainage entering the Grassland Area as described in James and others (1988). The first nine monitoring stations (I-1 to I-10) listed in Table 2 represent inflow into the South Grassland Area. The remaining two inflow stations (I-11 to I-12) either discharge to sloughs or the North Grassland Area (Figure 2).

Table 2. Median Constituent Concentrations for Grassland Area Drains During WY 89 (10/88 through 9/89).

Map ID	Monitoring Site	EC umhos/cm	Median Constituent Concentrations mg/L B	Cl	SO4	µg/L Se	Mo	Cr	Cu	Ni	Pb	Zn
	Inflow Sites											
I-1	Main (Firebaugh) Drain @ Russell	2980	3.9	315	835	49	13	17	9	19	<5	23
I-2	Panoche Drain/O'Banion	4180	6.5	520	1000	69	6	32	5	8	<5	11
I-3	Agatha Inlet (Mercy Springs) Drain	3660	7.6	435	895	6.7	–	–	–	–	–	–
I-4	Agatha Canal	880	0.36	130	100	2.9	2	–	–	–	–	–
I-6	Hamburg Drain	5120	5.7	660	1500	95	5	16	2	<5	<5	6
I-7	Camp 13 Slough	3750	5.2	440	940	59	8	–	–	–	–	–
I-8	Charleston Drain	4400	3.8	520	1400	66	3	25	12	17	<5	33
I-9	Almond Drive Drain	2160	2.2	190	420	3.7	–	–	–	–	–	–
I-10	Rice Drain	2750	5.4	280	670	3.1	14	–	–	–	–	–
I-11	Boundary Drain	1440	0.53	240	190	1.0	–	–	–	–	–	–
I-12	Salt Slough/Hereford	1070	0.36	160	140	1.2	–	–	–	–	–	–
	Internal Flow Sites											
T-1	CCID Main Canal/Russell	700	0.26	94	68	1.7	–	–	–	–	–	–
T-7	San Luis Canal/HWY 152	1050	0.76	135	140	2.5	–	–	–	–	–	–
	Outflow Sites											
O-1	Mud Slough / NGC	2310	1.7	325	385	2.1	–	–	–	–	–	–
O-2	Mud Slough/HWY 140	3000	2.4	425	480	2.1	11	9.5	4	<5	11.5	12
O-3	Los Banos Creek/HWY 140	1630	1.0	240	200	0.9	–	–	–	–	–	–
O-4	Salt Slough/Lander Ave.	2040	1.9	270	430	15	6	12.8	5.8	1.3	11.6	18.4

All results are reported as total recoverable

Continuing the trend found by James and others (1988) and Chilcott and others (1989), the inflows that carry a substantial portion of subsurface drainage water, the Main (Firebaugh) (I-1), Panoche (I-2), Agatha Inlet (Mercy Springs) (I-3), Hamburg (I-6), and Charleston (I-8) Drains, had elevated salinity levels. The Hamburg Drain had the highest median EC (5120 µmhos/cm), sulfate (1500 mg/L) and chloride (660 mg/L) values. The highest median boron (7.6 mg/L) occurred in the Agatha Inlet (Mercy Springs) Drain.

Internal Flow Monitoring Stations:

The internal flow monitoring stations were located on drains that carry or could carry subsurface agricultural drainage as it passes through the Grassland Area as described by James and others (1988). Only two of the original internal flow monitoring stations, the CCID Main at Russell Avenue (T-1) and the San Luis Canal at Highway 152 (T-7), were monitored during WY 89. These two stations represent concentrations in the main water supply source canals to the Grassland Area. The median EC, boron, chloride, and sulfate values recorded during this study for each of the internal flow monitoring stations are listed in Table 2.

The water in the CCID Main represents the quality of the Delta Mendota Canal water used to supply farms in the area. The quality of the water in the San Luis Canal also represents supply water, but may carry a quantity of tile drainage as shown by the elevated EC and boron levels. The existence of tile drainage is further demonstrated by the sulfate levels exceeding those of chloride, a characteristic shown strongly in the inflow drains (I-1 through I-10) into the South Grasslands Area.

Outflow Monitoring Stations:

Mud Slough (north) and Salt Slough are the only two tributaries to the San Joaquin River which drain the Grassland Area and are described in detail by James and others (1988), Pierson and others (1989a and b). Mud Slough (north) at Highway 140 (O-2) and Salt Slough at Lander Avenue (O-4) are the principle stations in this monitoring program . These two sloughs best represent the water quality of the drainage leaving the Grassland Area. During this study, Mud Slough (north) at Highway 140 had EC values ranging from 1100 to 6790 μmhos/cm with a median of 3000 μmhos/cm. Boron at this site ranged from 0.68 to 5.4 mg/L with a median value of 2.4 mg/L. Although quality continued to be poor in Mud Slough (north), the median value for boron continued a decreasing trend observed in WY 88 (Table 3). This decrease shows the impact of significantly reduced drainage water discharges into the Slough during WY 89.

Salt Slough at Lander Avenue (O-4) is the last monitoring station before Salt Slough discharges to the San Joaquin River. During this study, Salt Slough at Lander Avenue had EC values ranging from 1270 to 3400 μmhos/cm with a median value of 2040 μmhos/cm, and boron values ranging from 0.67 to 3.9 mg/L with a median of 1.9 mg/L (Appendix C). EC and boron concentrations at this site were less variable this year because of the frequent use of this Slough to divert drainage to the San Joaquin River. Concentrations at this site are generally lower than the South Grassland inflow monitoring stations due to additional dilution that occurs as the drainage water moves further downstream within the Grassland area. Median concentrations for salinity and boron are lower in Salt Slough than in Mud Slough (north).

Trace Elements

Although selenium was monitored at every site and molybdenum at a majority of sites, analyses of additional trace elements were limited based on the overall low concentrations found by James and others (1988). Total recoverable selenium, molybdenum, copper, chromium, lead, nickel, and zinc are listed in Appendices A through C for inflow, internal flow, and outflow monitoring stations, respectively. The ranges and median concentrations for each measured trace element constituent at each monitoring station are also listed in these appendices. The median trace element concentrations at each of the stations for WY 89 are tabulated in Table 2.

Inflow Monitoring Stations:

The highest median trace element concentrations occurred at the South Grassland inflow stations (I-1 to I-10), where the median selenium values ranged from 1.0 μg/L at Boundary Drain at Fish and Game Pumps (I-11) to 95 μg/L at Hamburg Drain (I-6). The Main (Firebaugh) (I-1), Panoche (I-2), Hamburg (I-6), and

Table 3. Median Constituent Concentrations for Grassland Area Drains During Water Years 85, 86, 87, 88 and 89 (Data for WY's 85, 86, and 87 from James et al., 1988, and for WY 88 from Chilcott et al., 1989).

			Median Constituent Concentrations									
Map	Monitoring Site	umhos/cm	---------mg/L---------			--------------------------ug/L--------------------------						
ID	Water Year	EC	B	Cl	SO4	Se	Mo	Cr	Cu	Ni	Pb	Zn
I-1	Main (Firebaugh) Drain @ Russell											
	Dry WY 85	2400	3.2	230	693	35	--	--	--	--	--	--
	Wet WY 86	2700	3.5	250	900	46	14	16	9	27	--	14
	Critical WY 87	2600	3.4	270	630	42	9	19	9	22	--	28
	Critical WY 88	3000	3.6	320	790	49	10	22	12	22	<5	29
	Critical WY 89	2980	3.9	315	835	49	13	17	9	19	<5	23
I-2	Panoche Drain @ O'Banion											
	Dry WY 85	3500	6.5	460	985	38	3	--	--	--	--	--
	Wet WY 86	3400	5.8	390	800	56	6.1	26	5.5	15	--	15
	Critical WY 87	4375	7.8	550	1075	47	2.5	40	10	13	--	18
	Critical WY 88	3650	6.4	440	890	54	3	43	12	21	<5	29
	Critical WY 89	4180	6.5	520	1000	69	6	32	5	8	<5	11
I-3	Mercy Springs Drain (Agatha Inlet Drain)											
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	3300	7.2	360	1000	14	10	7	5	13	--	10
	Critical WY 87	3125	7.0	302	800	6	16	5	3	7	--	3
	Critical WY 88	4150	8.6	540	1300	7.9	39	10	5	15	<5	12
	Critical WY 89	3655	7.6	435	895	6.7	–	–	–	–	–	–
I-4	Agatha Canal											
	Dry WY 85	2600	4.9	315	1100	26	1	--	--	--	--	--
	Wet WY 86	3300	5.6	400	900	44	<5	13	9	21	--	16
	Critical WY 87	3305	5.6	410	760	38	6	22	7	12	--	12
	Critical WY 88	3550	5.6	430	895	39	3	--	--	--	--	--
	Critical WY 89	880	0.36	130	100	2.9	2	–	–	–	–	–
I-6	Hamburg Drain											
	Dry WY 85	3200	3.8	435	900	47	6	--	--	--	--	--
	Wet WY 86	3250	4.0	400	1000	51	4	13	5	10	--	13
	Critical WY 87	3345	3.7	420	925	58	<5	17	5	8	--	10
	Critical WY 88	3600	4.1	450	1050	56	5	11	5	<5	<5	6
	Critical WY 89	5120	5.7	660	1500	95	5	16	2	<5	<5	6
I-7	Camp 13 Slough											
	Dry WY 85	2550	3.4	280	745	32	4	--	--	--	--	--
	Wet WY 86	2950	3.9	375	905	43	<5	14	7	20	--	16
	Critical WY 87	2650	3.7	280	590	43	6	30	11	13	--	19
	Critical WY 88	4400	6.2	500	1050	43	4	--	--	--	--	--
	Critical WY 89	3750	5.2	440	940	59	8	–	–	–	–	–
I-8	Charleston Drain											
	Dry WY 85	3900	2.6	395	1275	48	--	--	--	--	--	--
	Wet WY 86	4500	4.7	510	1580	93	7.9	9	10	14	--	18
	Critical WY 87	3855	4.2	480	1035	79	2	32	12	22	--	50
	Critical WY 88	4450	4.5	520	1300	71	3	31	13	27	--	47
	Critical WY 89	4400	3.8	520	1400	66	3	25	12	17	<5	33
I-9	Almond Drive Drain											
	Dry WY 85	1520	1.6	160	340	2	--	--	--	--	--	--
	Wet WY 86	--	--	--	--	--	--	--	--	--	--	--
	Critical WY 87	1925	2.1	224	395	4.8	4.5	28	11	21	--	25
	Critical WY 88	2300	2.1	230	460	4.6	--	18	7	13	--	15
	Critical WY 89	2160	2.2	190	420	3.7	–	–	–	–	–	–
I-10	Rice Drain											
	Dry WY 85	2450	5.7	245	715	2.5	--	--	--	--	--	--
	Wet WY 86	3300	8.1	350	1080	3	14	5	6	23	--	13
	Critical WY 87	2500	6.1	260	550	2.6	11	3	3	6	--	<1
	Critical WY 88	2790	5.1	310	700	2.6	15	--	--	--	--	--
	Critical WY 89	2745	5.4	280	673	3.1	14	--	--	--	--	--

Table 3. Median Constituent Concentrations for Grassland Area Drains During Water Years 85, 86, 87, 88 and 89 (Data for WY's 85, 86, and 87 from James et al., 1988, and for WY 88 from Chilcott et al., 1989).

Map ID	Monitoring Site / Water Year	umhos/cm EC	Median Constituent Concentrations mg/L B	Cl	SO4	ug/L Se	Mo	Cr	Cu	Ni	Pb	Zn
I-11	Boundary Drain											
	Dry WY 85	1090	0.45	195	135	1	--	--	--	--	--	--
	Wet WY 86	1710	0.65	250	210	1	6	2	7	9	--	14
	Critical WY 87	1250	0.54	200	145	1.6	4	<1	2	<5	--	3
	Critical WY 88	1470	0.50	230	180	1.4	6	--	--	--	--	--
	Critical WY 89	1435	0.53	240	190	1.0	–	--	--	--	--	--
I-12	Salt Slough @ Hereford											
	Dry WY 85	850	0.37	120	100	1	--	--	--	--	--	--
	Wet WY 86	785	0.33	100	99	1	<5	3	5	9	--	22
	Critical WY 87	1000	0.39	130	120	1.4	3	1	2	<5	--	2
	Critical WY 88	1150	0.38	160	140	1.2	5	--	--	--	--	--
	Critical WY 89	1070	0.4	160	140	1.2	–	--	--	--	--	--
T-1	CCID Main Canal @ Russell											
	Dry WY 85	430	0.21	72	35	<1	--	--	--	--	--	--
	Wet WY 86	385	0.21	53	47	1.3	<5	3	3	5	--	8
	Critical WY 87	570	0.28	65	58	2.2	<5	1	3	<5	--	3
	Critical WY 88	760	0.29	120	65	1.7	--	--	--	--	--	--
	Critical WY 89	700	0.26	94	68	1.7	--	--	--	--	--	--
T-7	San Luis Canal @ HWY 152											
	Dry WY 85	1550	1.4	180	295	4.5	--	--	--	--	--	--
	Wet WY 86	1200	1.4	130	200	2	<5	4	4	10	--	9
	Critical WY 87	2630	3.4	260	520	4	<5	3	3	<5	--	7
	Critical WY 88	2550	3.6	280	570	3.9	--	--	--	--	<5	--
	Critical WY 89	1045	0.76	135	140	2.5	--	--	--	--	–	–
O-1	Mud Slough @ NGC											
	Dry WY 85	-	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	1800	2.0	215	330	4	5	9	5	11	--	15
	Critical WY 87	2600	2.4	300	420	5.1	13	7	4	10	--	1
	Critical WY 88	2480	2.2	330	440	4.7	--	--	--	--	--	--
	Critical WY 89	2310	1.7	325	385	2.1	--	--	--	--	--	--
O-2	Mud Slough @ HWY 140											
	Dry WY 85	2600	3.1	305	525	13	--	--	--	--	--	--
	Wet WY 86	2300	3.0	280	630	8.5	8	6	5	14	--	11
	Critical WY 87	2600	3.0	320	540	17	9	12	9	11	--	7
	Critical WY 88	2820	2.7	350	510	9.3	11	--	--	--	--	--
	Critical WY 89	3000	2.4	425	480	2.1	11	9.5	4	<5	11.5	12
O-3	Los Banos Creek @ HWY 140											
	Dry WY 85	--	--	--	--	--	--	--	--	--	--	--
	Wet WY 86	2200	2.3	430	300	1	<5	6	8	18	--	17
	Critical WY 87	1855	1.6	215	215	1.4	--	--	--	--	--	--
	Critical WY 88	1690	1.2	230	210	1.1	--	--	--	--	--	--
	Critical WY 89	1630	1.0	240	200	0.9	--	--	--	--	--	--
O-4	Salt Slough @ Lander Ave.											
	Dry WY 85	1250	0.96	185	195	4.5	--	--	--	--	--	--
	Wet WY 86	1610	1.3	240	245	7.4	7	4	6	12	--	18
	Critical WY 87	1720	1.7	250	350	12	6	6	4	6	--	4
	Critical WY 88	1940	1.9	260	385	13	6	--	--	--	--	--
	Critical WY 89	2040	1.9	270	430	15	6	12.8	5.8	1.3	11.6	18.4

Water Years (WY) run from 1 October through 30 September.

Charleston Drains (I-8) had high median selenium concentrations; however, as with salinity and boron discussed earlier, the concentrations are highly dependent upon the amount of dilution water in the canal or drain at the time of sampling. Due to the continued drought, total recoverable selenium concentrations have been found in excess of 100 μg/L at Main (Firebaugh) Drain (two times), Charleston Drain (one time), Hamburg Drain (three times), and Panoche Drain (three times) indicating that little surface runoff was available for dilution at that time. Selenium concentrations exceeded 100 μg/L at Camp 13 one time, peaking at 123 μg/L in late March 1989. Camp 13 receives water from a mixture of drains including Main, Hamburg, and Panoche Drains. These higher concentrations occurred primarily during the non-irrigation season (October - March) when drainage flow was very low and dilution water was scarce. Concentrations in the Hamburg Drain, however, remained strongly elevated throughout the entire irrigation season with a median value for the year at 95 μg/L.

The Main Drain (I-1) and Rice Drain (I-10) had the highest median molybdenum concentrations at 13 μg/L and 14 μg/L, respectively. The remaining inflow drains had a median molybdenum concentrations ranging from 2 μg/L to 8 μg/L.

Internal Flow Monitoring Stations:

Selenium was the only trace element measured at both internal flow monitoring stations. From October 1988 through September 1989, CCID Main Canal at Russell Avenue (T-1) had selenium concentrations ranging from 0.7 μg/L to 2.4 μg/L with a median concentration of 1.7 μg/L. During the same period, selenium concentrations at San Luis Canal at Hwy 152 (T-7) ranged from 1.2 μg/L to 3.3 μg/L with a median concentration of 2.5 μg/L.

Outflow Monitoring Stations:

Selenium was monitored at all four outflow stations, molybdenum was monitored at two stations (O-2 and O-4). The median concentrations detected during this study are tabulated in Table 2.

Selenium concentrations at the furthest downstream monitoring station on Salt Slough at Lander Avenue (O-4), ranged from 2.7 to 38 μg/L with a median of 15 μg/L. Selenium concentrations for Salt Slough were elevated over those seen in previous years (Table 3).

Selenium concentrations in Mud Slough (north) at Highway 140 (O-2) ranged from 0.7 to 13 μg/L with a median of 2.1 μg/L. Los Banos Creek flows into Mud Slough (north) downstream of the Highway 140 monitoring station and it has a diluting effect on the Slough with respect to selenium as measured at the Newman Land and Cattle Company station (O-1). Los Banos Creek receives its flow from the western portion of the North Grassland Area and from areas west of the study area. The creek receives little subsurface drainage. In WY 89, selenium concentrations ranged from 0.3 to 2.5 μg/L with a median of 0.9 μg/L at the Los Banos Creek at Highway 140 station (O-3). The downstream Mud Slough (north) station (O-1) had a lower selenium concentration range than site O-2 with values ranging from 0.7 to 5.0 μg/L and a median of 2.1 μg/L.

DISCUSSION

The current study shows that water quality within the Grassland Area continues to vary widely with the highest constituent concentrations found at the inflow monitoring stations near the southern border of the study area. This inflow water is generally a blend of subsurface tile drainage and surface runoff (tailwater) or operational spills from irrigation canals. Four of these inflow points listed in Table 1 (I-1, I-2, I-6, and I-8) carry a substantial portion of subsurface drainage water. The highest concentrations at these four sites likely reflect a greater proportion of tile drainage in the flow and not necessarily the quality of subsurface drainage being discharged at the tile drainage sumps. A synoptic survey of the quality at the tile drainage sumps has been conducted and can be referenced for quality further upstream (Chilcott et al., 1988).

The sites inflowing from the south and southeast continue to carry the highest concentrations of salts, boron, and selenium. Other inflows contain little selenium, however elevated levels of salt and boron are present. For example, the median values for selenium at the four major southern inflow points ranged from 49 to 95 μg/L while other southern inflow points showed median selenium values ranging from 2.9 to 6.7 μg/L. The two inflow sites carrying water from areas east of the Grasslands (I-11 and I-12) contained the lowest median selenium concentrations (1.0 and 1.2 μg/L, respectively). Water at these sites is primarily drainage from Sierran deposits which have been reported to have low selenium concentrations (Deverel et al., 1984).

For boron, the four drains carrying the high selenium water showed median boron values ranging from 3.8 to 6.5 mg/L while the other southern inflow drains that have low selenium values showed median boron values ranging from 2.2 to 7.6 mg/L. Median concentrations were lowest for sites I-4, I-11, and I-12 (0.36, 0.52, and 0.36 mg/L, respectively); drains which contain a combination of agricultural drainage and fresh supply water.

Concentrations at the internal flow and outflow monitoring stations, in past years, were comparable to each other and were substantially lower than the southern inflows. The water quality reflects the amount of mixing and dilution that takes place as drainage water moves through the Grassland Area. The flows are strongly regulated by an extensive system of man-made structures and trends in water quality are difficult to identify. However, water quality at the outflow stations has reflected the lower dilution resulting from less surface water available in the critically dry years.

Data for this study includes information for WY 89 which is the third consecutive critically dry water year. Tabulated in Table 3 are median constituent concentrations by water year for all the study monitoring sites since 1985. Median concentrations were listed for WY 85 where available, however the 1985 data set may be incomplete for some locations. Concentrations for all the drains and sloughs were routinely higher during the critically dry Water Years 1987-89 than during the wet Water Year 1986. The elevated concentrations may be due in part to increased influence of the shallow groundwater as well as a decrease in dilution from irrigation spill water or tailwater runoff. The decrease in irrigation spill water or tailwater may be due to more efficient use of limited supply water.

The few exceptions to the general increase in concentrations are the Agatha Canal, Charleston Drain, Rice Drain, Boundary Drain, and Los Banos Creek at Hwy. 140. At various times of the year, the Agatha Canal can carry agricultural drainage (subsurface and tailwater), supply water (purchase and operational spill), or a mixture of the two. The Rice Drain and Boundary Drain provide inflow to the eastern portion of the study area. Los Banos Creek is a natural stream channel which drains the coastal foothills, but carries a substantial portion of tailwater and operational spill water. The Charleston Drain carries a substantial percent of subsurface agricultural drainage from the southwest portion of the study area. The lower observed concentrations during the critical water years have not been explained.

The two main outflows, Mud Slough (north) and Salt Slough were monitored during the study. These sites represent water quality of the blended drainage flowing from the Grassland Area to the San Joaquin River. The quality of both sloughs varied widely depending upon which slough was carrying the greatest portion of subsurface tile drainage water. During WY 89, Salt Slough appeared to carry a greater proportion of tile drainage water as evident in higher overall selenium concentrations. For example, Salt Slough selenium concentrations ranged from 2.7 to 38 μg/L with a median of 15 μg/L. Mud Slough showed a similar, but lower, variability with a median selenium value of 2.1 μg/L. Tile drainage water is reported to contribute 95 percent of the selenium in the grassland area (SWRCB, 1987).

During wet WY 86, the median boron concentration at Salt Slough at Lander Avenue was 1.3 mg/L. During the drier years, WY 87, 88, and 89, median concentrations increased to 1.7 mg/L, 1.9 mg/L, and 1.9 mg/L, respectively. Although median boron concentrations did not increase directly for Mud Slough at Hwy. 140, peak monthly concentrations were higher on a number of occasions.

Selenium followed a similar trend for a wet and critical years in Salt Slough and Mud Slough (north). Median values in Salt Slough increased from 7.4 μg/L to 12 μg/L, 13 μg/L, and 15 μg/L for WY 86, WY 87, WY 88, and WY 89, respectively. Selenium values in Mud Slough (north) also showed an increasing trend although the highest median concentration peaked in WY 87 at 17 μg/L while WY 88 showed 9.3 μg/L. WY 86, a wet year, showed 8.5 μg/L median selenium concentrations in Mud Slough (north). The lowest overall median selenium concentration (2.1 μg/L) was detected during WY 89 and may be more reflective of water management procedures than Water Year type.

Figures 3 through 6 present boron and selenium concentrations for Mud Slough (north) and Salt Slough for wet WY 86 and critically dry WYs 88 and 89. As can be seen in Figures 3 and 4, the time of year concentration patterns for Salt Slough reflect the patterns shown in James et al., (1988), and Chilcott et al. (1989). The concentrations tend to increase during the non-irrigation period (October to March) and decrease during the irrigation period (April to September). During the non-irrigation period, flows in the drains and canals consist mainly of shallow groundwater seepage and subsurface drainage. These two water types have been shown to contain elevated levels of a number of constituents including selenium (Lowry et al., 1989; Deverel et al., 1984; and Chilcott et al., 1988). During the irrigation season, a large proportion of the flow in the Grassland Area drains consists of surface agricultural runoff (tailwater) which dilutes the subsurface agricultural drainage, thus lowering the selenium concentrations. During the non-irrigation season, there is no surface runoff, so the drains carry a higher proportion of subsurface agricultural drainage, and

Figure 3. Boron Concentrations in Salt Slough at Lander Ave. for WY86, WY88, and WY89.

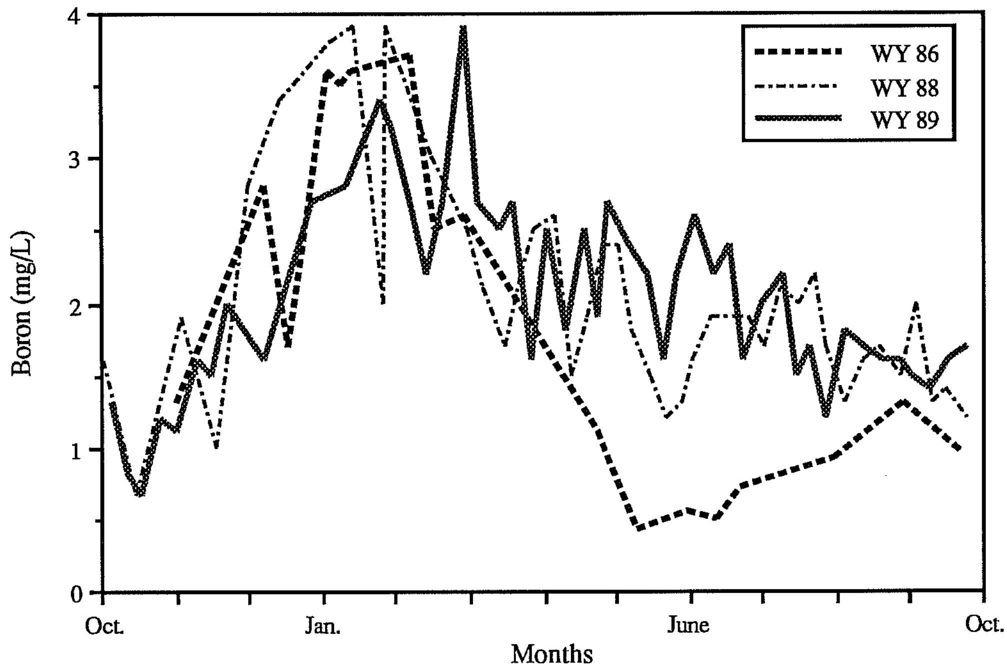


Figure 4. Selenium Concentrations in Salt Slough at Lander Ave. for WY86, WY88, and WY89.

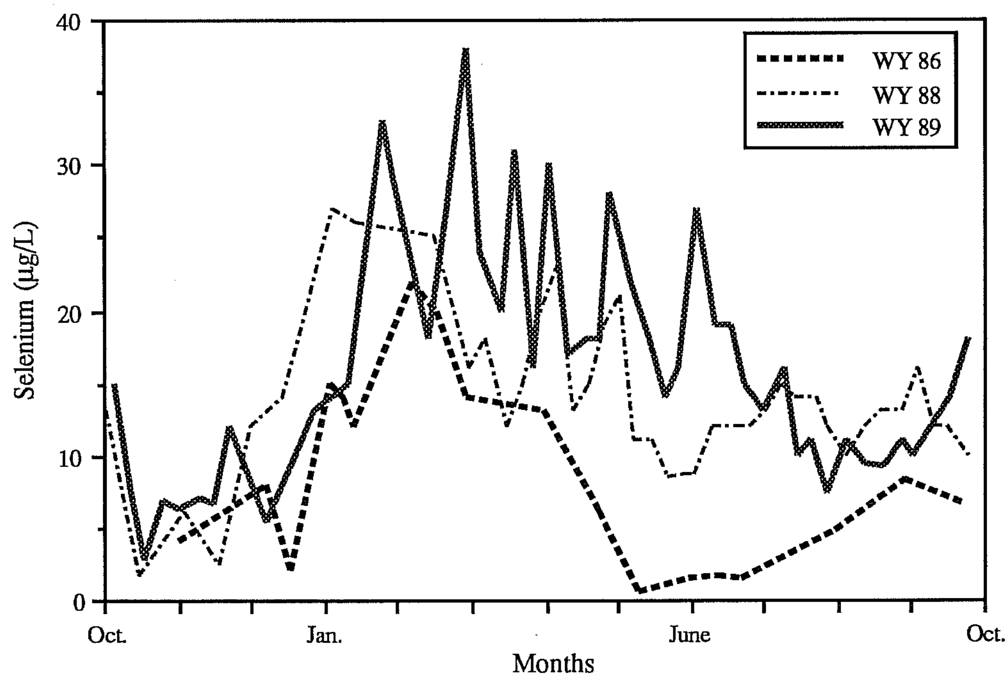


Figure 5. Boron Concentrations in Mud Slough (North) at Highway 140 for WY86, WY88, and WY89.

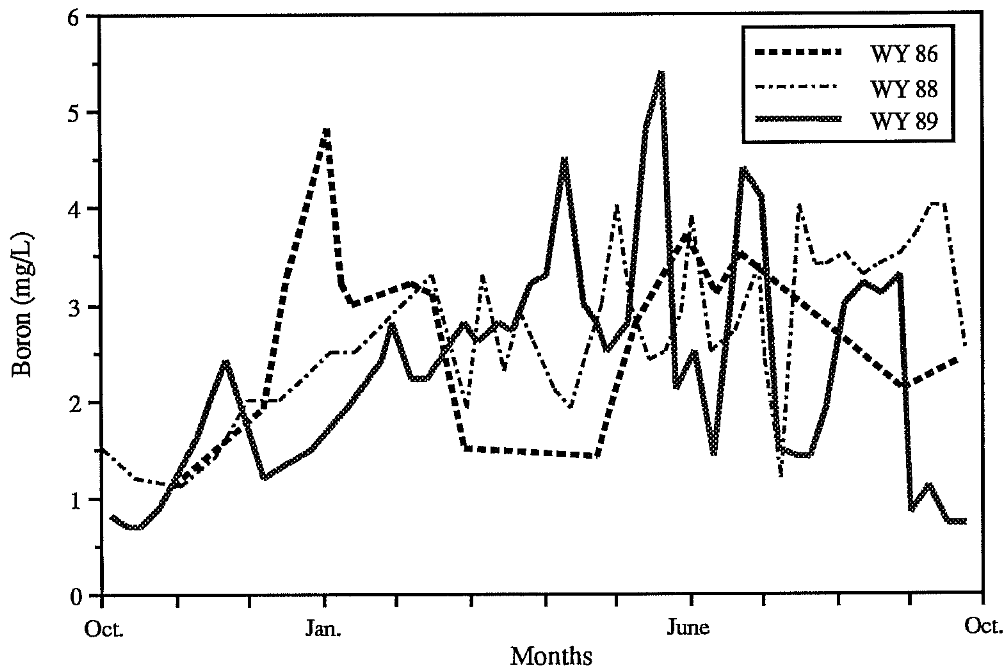
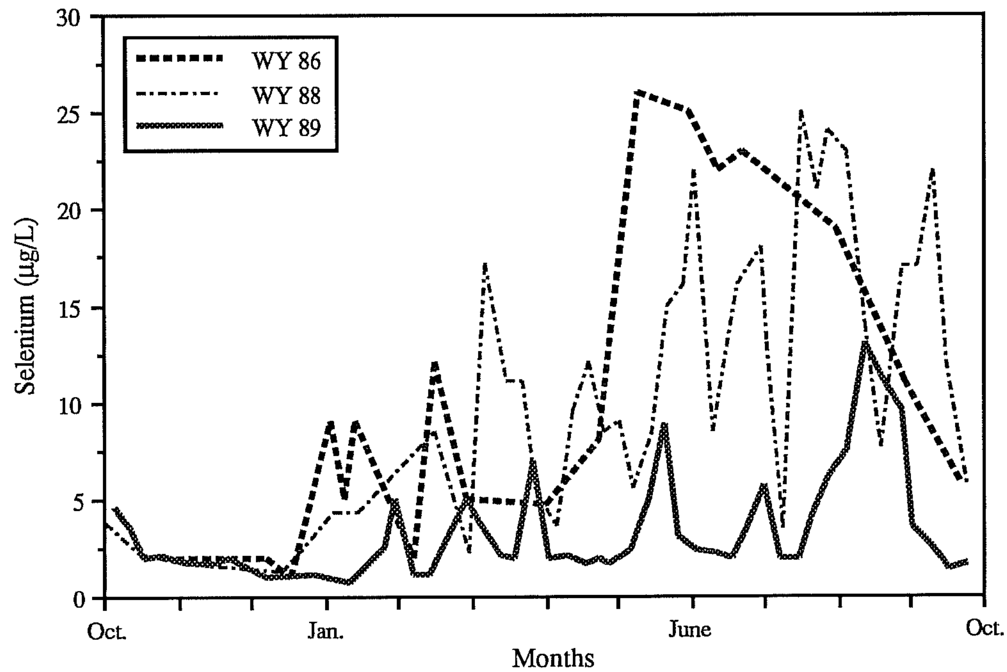


Figure 6. Selenium Concentrations for Mud Slough (North) at Hwy 140 for WY86, WY88, and WY89.



consequently, selenium values are higher. The critically dry WYs concentrations have remained substantially higher than those seen during wet WY 86.

Throughout WY 89, selenium levels in Salt Slough were highly elevated when compared to Mud Slough (Figure 7). In addition, although the overall selenium concentration continued to peak during late January to early March (the tail end of the nonirrigation season), the concentrations did not decrease as rapidly as noted in previous reports (James et al., 1988 and Chilcott et al., 1989) once the irrigation season began. This slow decrease in concentration may be due in part to a reduced amount of tailwater flow for dilution due to recycling efforts encouraged in this third critically dry year. During WY 89, selenium concentrations in Salt Slough remained above 10 µg/L except for October and November 1988, while selenium concentration in Mud Slough only exceeded 10 µg/L in August 1989.

In contrast, boron and molybdenum concentrations were generally higher in Mud Slough as opposed to Salt Slough during WY 89 (Figures 8 and 9, respectively). Seasonal trends were slightly altered as well, with maximum boron and molybdenum concentrations in Mud Slough occurring between April and September, the peak irrigation season. Salt Slough, which appeared to carry a majority of the drainage water continued to show higher relative concentrations during the nonirrigation season. Mud Slough flows appeared to be primarily composed of ground water seepage. The shallow ground water in the vicinity of Mud Slough contains elevated levels of boron and molybdenum (Chilcott et al., 1988 and Regional Board, 1988). Some dilution of the natural shallow ground water may be occurring during the nonirrigation season from the floodup of surrounding duck clubs.

Chromium continues to be an element of concern. Chromium is commonly found in shallow ground water in the western San Joaquin Valley south of the study area, especially in water derived from alluvial fan deposits (Deverel et al., 1984, and Chilcott et al., 1988). The highest chromium concentrations found in this monitoring program occurred in the Panoche Drain which receives its flow from areas with alluvial fan deposits. Ambient water quality criteria for chromium is based on concentrations of the hexavalent chromium species. This monitoring program measured total recoverable chromium; therefore, the current reported data can not be directly compared to the criteria. However, during WY 89, median values of total recoverable chromium routinely exceeded the hexavalent chromium four-day average ambient water quality criteria of 11 µg/L for the protection of freshwater aquatic life. Five of the eight drains monitored had median total chromium concentrations exceeding 16 µg/L, the one-hour average hexavalent chromium criteria for protection of aquatic life (EPA, 1985).

Since chromium is closely associated with the sediment, the monitoring program has been altered to analyze dissolved chromium as well as total recoverable chromium in downstream stations along the San Joaquin River. Due to the high suspended sediment concentrations in downstream samples, dissolved chromium concentrations would closer approximate hexavalent values due to the fact that hexavalent chromium would be found in a soluble form in most natural surface waters. Analysis for acid soluble hexavalent chromium would be needed to evaluate the impact of chromium on the quality of water in terms of aquatic life for these drains. A survey of hexavalent chromium at and upstream of inflow monitoring stations (areas where total chromium concentration appear the highest) has been conducted by Regional Board staff and will be reported separately.

Figure 7. Selenium Concentrations in Mud Slough @ Hwy. 140 and Salt Slough @ Lander Ave. Water Year 1989

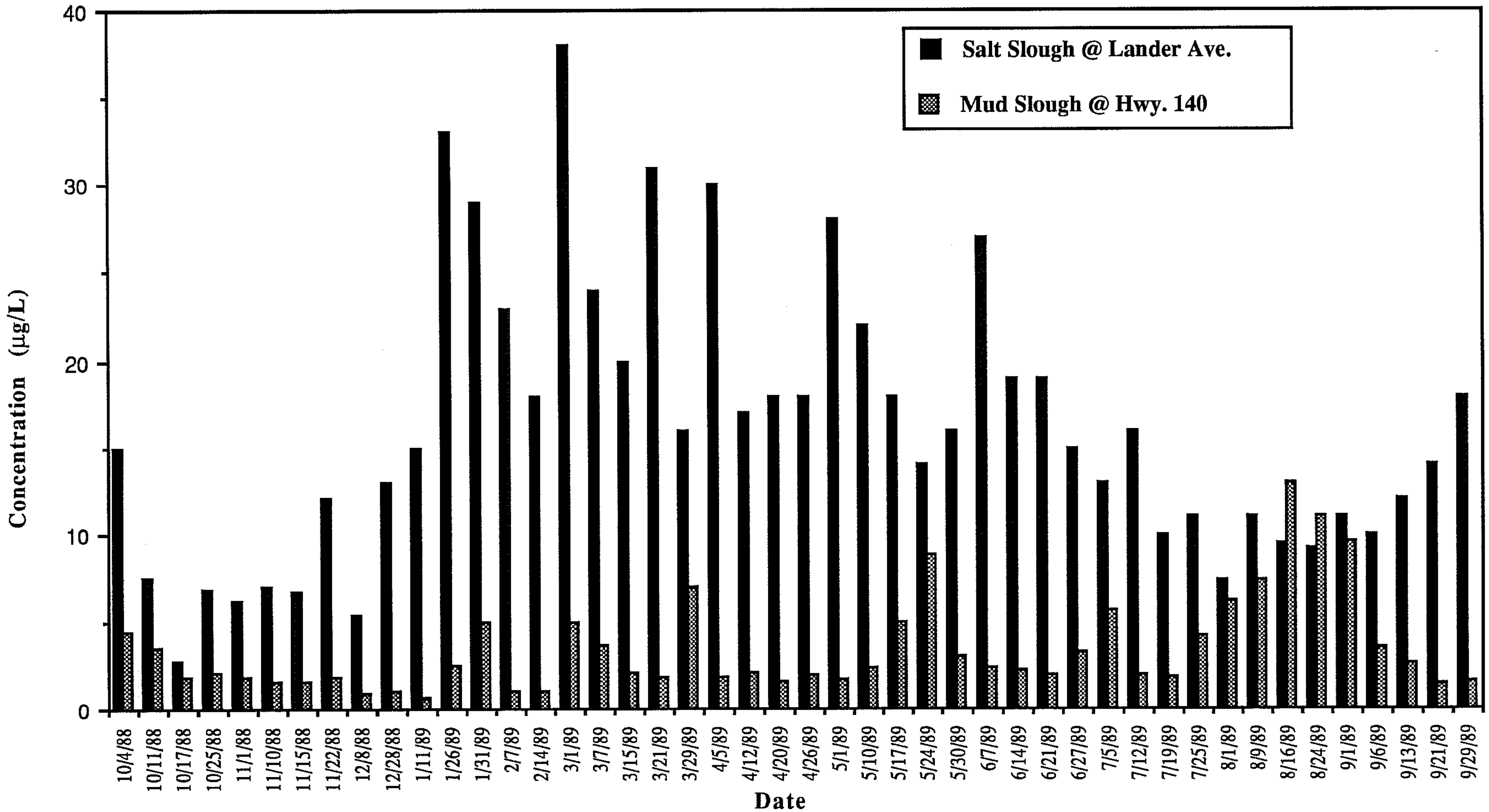


Figure 8. Boron Concentrations in Mud Slough @ Hwy. 140 and Salt Slough @ Lander Ave.
Water Year 1989

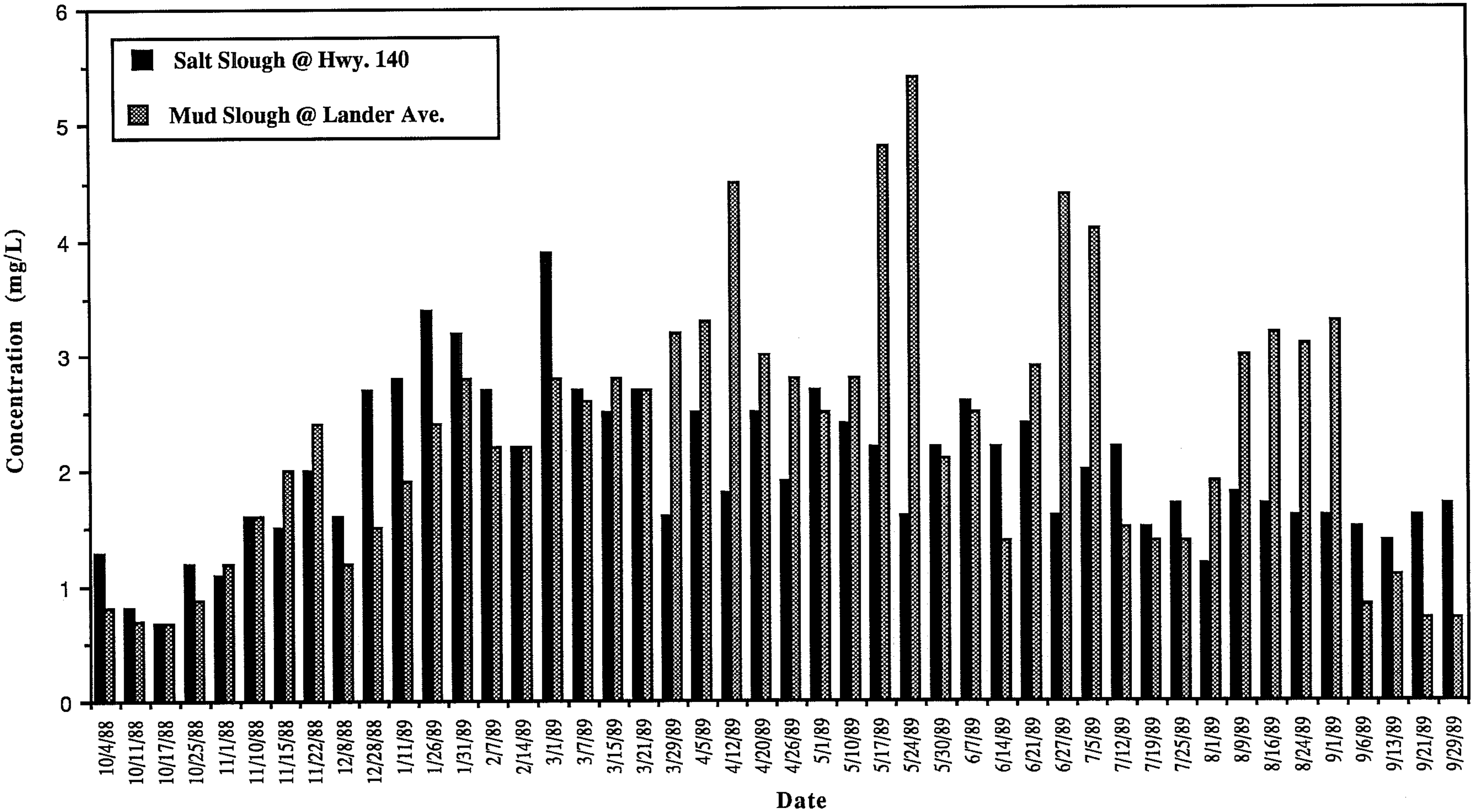
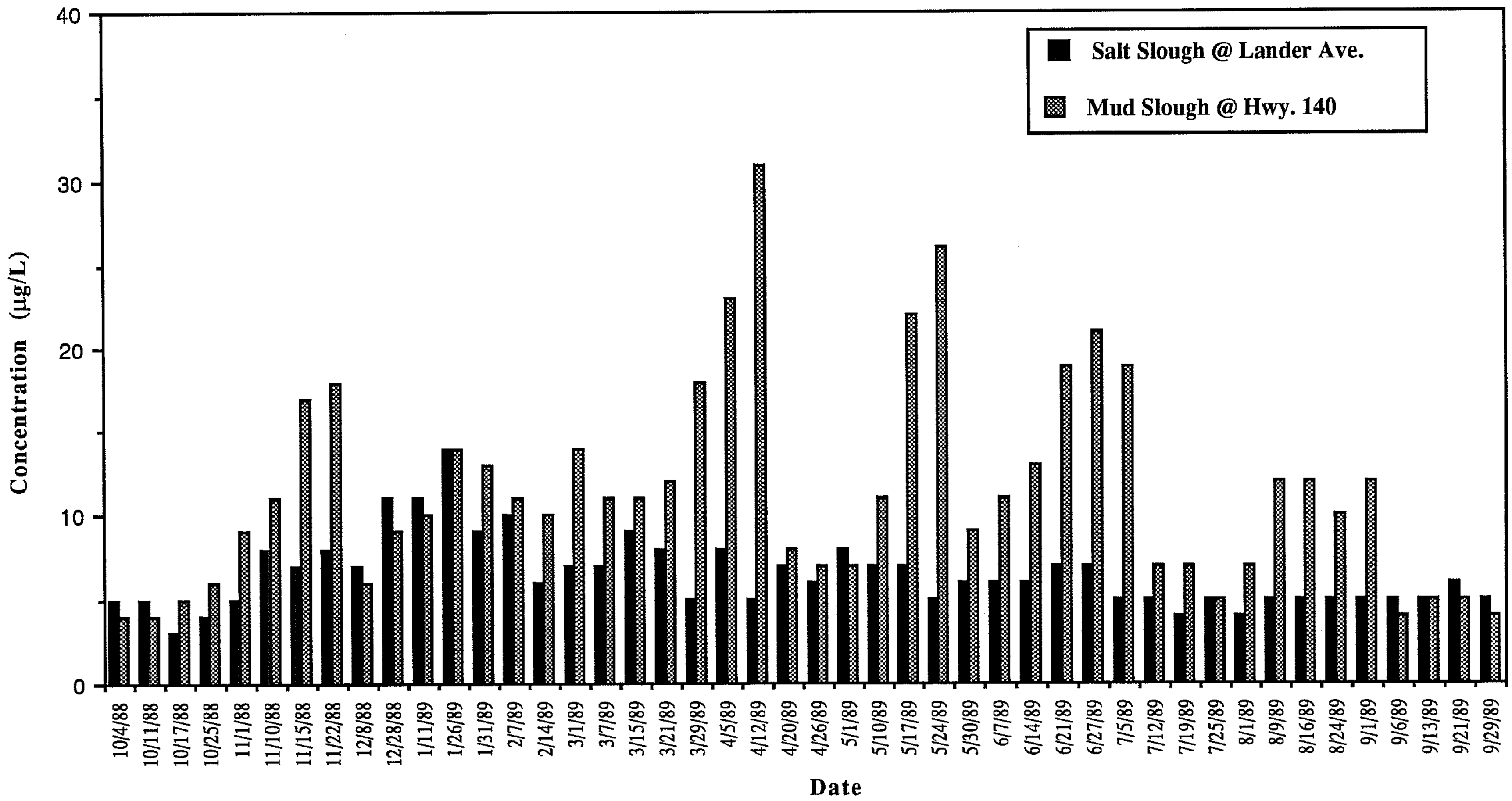


Figure 9. Molybdenum Concentrations in Mud Slough @ Hwy. 140 and Salt Slough @ Lander Ave. Water Year 1989



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APPENDIX A

Mineral and Trace Element Water Quality Data for Inflow Monitoring Stations
Listed in Order by Map Index Number

Map Index I-1. Main (Firebaugh) Drain at Russell Avenue (MER556)

Location: Latitude 36° 55'27", Longitude 120°39'11". In SW 1/4, SW 1/4, SW 1/4, Sec. 34, T.11S., R.12E. E side of Russell Avenue., 2.7 mi. S of South Dos Palos.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk.	Temp.
			µmhos/cm	µg/L							mg/L						°F
10/4/88	1420		3060	52	11	12	22	27	<5	31	3.7	310	760	<1	140	140	64
11/1/88	1450	7.8	2050	27	9	10	20	21	<5	32	1.8	220	480	<1	120	120	64
12/8/88	1640		4770	68	45	3	6	8	<5	7	6.7	470	1300	<1	170	170	50
1/11/89	1230		4900	119	31	3	17	6	<5	5	7.0	540	1500			150	49
2/7/89	1230	8.0	2700	44	2	8	13	14	<5	16	2.2	320	820	<1	130	130	43
3/1/89	1430	7.9	5100	127	24	5	15	13	<5	13	5.6	570	1400	<1	170	170	55
3/29/89	1445	7.5	3650	74	26	6	10	10	<5	10	4.5	380	1300	<1	280	280	67
5/1/89	1500	7.6	3110	61	15	10	22	18	<5	23	3.5	350	940	<1	140	140	70
5/30/89	1505	8.0	2860	38	1	8	16	16	<5	20	4.00	270	850	<2	130	130	73
7/5/89	1215	7.6	2900	47	13	9	16	19	<5	24	4.0	230	760	7	130	137	76
8/1/89	850	8.1	2060	35	7	13	25	28	<5	40	2.5	160	450	<2	120	120	71
9/1/89	948	8.1	2400	30	12	9	16	20	<5	23	3.2	220	610	<2	170	170	68
MIN		7.5	2050	27	1	3	6	6	<5	5	0.20	41	43	<1	66	66	43
MED		7.9	2980	49	13	9	16	17	<5	22	3.9	315	835	<1	140	140	66
MAX		8.1	5100	127	45	13	25	28	<5	40	7.0	570	1500	7	280	280	76
COUNT		9	12	12	12	12	12	12	12	12	12	12	12	11	11	12	12

Map Index I-2. Panoche Drain at O'Banion Gauge Station (MER501)

Location: Latitude 36°55'27", Longitude 120°41'19". In SW 1/4, SW 1/4, SW 1/4, Sec. 32, T. 11S., R.12E.
Located 0.5 mi. S of CCID Main Canal, 1.9 mi. W of Russell Rd., 5.5 mi. SW of Dos Palos,
3.4 SW of South Dos Palos.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk.	Temp.
			µmhos/cm	µg/L							mg/L						°F
10/4/88	1400		5090	118	10	5	19	8	<5	8	7.6	660	1300	<1	180	180	74
11/1/88	1435	8.2	4840	104	11	2	29	<5	<5	5	8.4	600	1200	<1	140	140	72
12/8/88	1555		3890	68	7	5	32	5	<5	40	6.4	490	820	<1	160	160	57
1/11/89	1250		4180	79	6	3	32	6	<5	6	6.5	520	1100			150	52
3/1/89	1415	7.8	4220	69	5	3	28	6	7	7	6.0	520	940	<1	180	180	57
3/29/89	1420	7.6	4700	105	5	5	33	8	<5	7	7.5	620	1400	<1	180	180	68
5/1/89	1445	7.7	4460	92	6	7	41	10	<5	15	7.2	630	1300	<1	180	180	72
5/30/89	1450	8.0	3920	53	6	6	24	12	<5	12	6.8	480	1000	<2	160	160	76
7/5/89	1200	7.8	3020	24	2	10	34	26	<5	29	5.3	350	490	11	140	151	75
8/1/89	830	8.0	3220	14	3	9	35	21	<5	25	5.7	370	800	<2	190	190	64
9/1/89	930	7.8	3650	49	6	4	18	10	<5	11	6.1	420	880	<2	210	210	66
MIN		7.6	3020	14	2	2	18	<5	<5	5	5.3	350	490	<1	140	140	52
MED		7.8	4180	69	6	5	32	8	<5	11	6.5	520	1000	<1	180	180	68
MAX		8.2	5090	118	11	10	41	26	<5	40	8.4	660	1400	11	210	210	76
COUNT		8	11	11	11	11	11	11	11	11	11	11	11	10	10	11	11

Map Index I-3. Agatha Inlet (Mercy Springs) Drain (Outlet) near Panoche Drain (MER552)

Location: Latitude 36°56'01", Longitude 120°42'05". In SE 1/4, SE 1/4, NW 1/4, Sec. 31, T. 11S., R.12E.
S of Firebaugh Drain, 2.6 mi. W of Russell Ave., 2.8 mi. S of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk.	Temp. °F
				µg/L						mg/L						
10/4/88	1350		3990	6.3	5	10	11	<5	11	7.2	520	920	<1	120	120	73
12/8/88	1620		3810	7.3	2	2	<5	<5	6	8.9	390	930	<1	160	160	50
2/7/89	1240	8.3	10650	26	4	7	11	<5	9	30	1200	4400	<1	220	220	40
3/1/89	1405	8.5	4430	8.5						9.6	450	1200	<1	170	170	56
3/29/89	1410	7.8	10090	17	4	6	11	<5	6	27	1200	4200	<1	190	190	77
5/1/89	1430	7.8	2560	7.1						4.4	300	740	<1	130	130	79
5/30/89	1445	8.0	3500	6.3						7.3	470	850	<2	180	180	82
7/5/89	1140	7.8	3350	5.0						6.9	420	840	<2	170	170	82
8/1/89	810	7.8	3490	6.2						7.8	390	870	11	190	201	66
9/1/89	920	8.0	2040	2.3						3.2	230	400	<2	200	200	69
MIN		7.8	2040	2.3						3.2	230	400	<1	120	120	40
MED		7.9	3660	6.7						7.6	435	895	<1	175	175	71
MAX		8.5	10650	26						30	1200	4400	11	220	220	82
COUNT		8	10	10						10	10	10	10	10	10	10

Map Index I-4. Agatha Canal at Helm Canal (MER506)

Location: Latitude 36°56'04", Longitude 120°41'06". In NE 1/4, Se 1/4, NW 1/4, Sec. 31, T.11S., R.12E. 150 ft. N of Helm Canal, 2.6 mi. W of Russell Ave., 3.4 mi. SW of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	CO3 mg/L	HCO3 mg/L	T.Alk mg/L	Temp. °F
10/4/88	1340		860	2.9	1	0.34	130	75	<1	92	92	72
11/1/88	1415	8.1	880	2.9	2	0.36	130	100	<1	91	91	68
3/1/89	1345	7.8	6060	8.8		8.5	730	1700	<1	220	220	60
7/5/89	1110	7.8	2940	35		4.8	330	790	10	140	150	76
9/1/89	855	8.5	490	2.0		0.21	61	50	<2	73	73	72
MIN		7.8	490	2.02	1	0.21	61	50	<1	73	73	60
MED		8.0	880	2.9	1.5	0.36	130	100	<1	92	92	72
MAX		8.5	6060	35	2	8.5	730	1700	10	220	220	76
COUNT		4	5	5	2	5	5	5	5	5	5	5

Map Index I-6. Hamburg Drain near Camp 13 Slough (MER504)

Location: Latitude 36°56'32", Longitude 120°45'23". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E.
50 ft. S of CCID main Canal, 9.2 mi. S-SE of Los Banos, 6.7 mi. W-SW of South Dos Palos.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk.	Temp.
			µmhos/cm	µg/L							mg/L						°F
10/4/88	1315		5370	81	5	2	17	<5	<5	5	6.3	740	1500	<1	100	100	73
11/1/88	1355	8.3	5090	95	5	2	14	<5	<5	10	4.6	660	1400	<1	88	88	71
12/8/88	1510		4890	84	6	3	16	<5	<5	6	4.7	610	1200	9	110	119	62
1/11/89	1140		5420	98	4	2	22	<5	<5	5	6.0	660	1500			130	52
2/7/89	1210	7.9	4150	70	2	8	24	17	<5	24	3.6	520	1100	<1	120	120	48
3/1/89	1325	7.7	5820	117	2	4	21	12	<5	13	5.9	760	1500	<1	160	160	64
3/29/89	1330	7.4	5120	96	2	6	30	12	<5	13	5.0	720	1700	<1	140	140	73
5/1/89	1355	7.7	5470	99	6	1	22	<5	<5	4	6.7	840	1600	<1	125	125	74
5/30/89	1410	8.0	6280	114	6	<1	16	<5	<5	3	7.9	840	1800	<2	130	130	77
7/5/89	1050	7.6	4420	69	3	3	12	7	<5	6	5.3	550	1200	<2	140	140	73
8/1/89	720	7.7	6150	105	5	<1	13	<5	<5	6	8.5	730	1700	<2	160	160	65
9/1/89	835	7.8	4910	72	5	2	12	<5	<5	5	5.7	610	1400	<2	150	150	65
9/29/89	725	7.4	4190	67	5	1	13	<5	<5	<1	4.5	500	1200	<2	130	130	64
MIN		7.4	4150	67	2	<1	12	<5	<5	3	3.6	500	1100	<1	88	88	48
MED		7.7	5120	95	5	2	16	<5	<5	6	5.7	660	1500	<1	130	130	65
MAX		8.3	6280	117	6	8	30	17	<5	24	8.5	840	1800	9	160	160	77
COUNT		10	13	13	13	13	13	13	13	13	13	13	13	12	12	13	13

Map Index I-7. Camp 13 Slough at Gauge Station (MER505)

Location: Latitude 36°56'04", Longitude 120°41'06". In SE 1/4, SE 1/4, SW 1/4, Sec. 27, T.11S., R.11E. 150 ft. N of CCID Main Canal, 6.4 mi. W of Russell Ave., 9.2 mi. SE of Los Banos, 6.7 mi. SW of South Dos Palos.

Date	Time	pH	EC	Se	Mo	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/cm	µg/L		mg/L						°F
10/4/88	1325		3740	65	8	5.2	440	910	<1	150	150	73
11/1/88	1400	8.0	3500	59	8	4.2	420	940	<1	140	140	69
12/8/88	1515		4250	72	12	6.3	520	980	<1	160	160	56
1/11/89	1150		3690	59	9	5.3	460	930			140	50
2/7/89	1220	7.9	3750	59	8	4.7	440	990	<1	160	160	46
3/1/89	1330	7.8	4290	80	9	5.4	500	1000	<1	170	170	57
3/29/89	1340	7.3	5020	123	13	7.3	620	1600	<1	180	180	69
5/1/89	1400	7.8	4040	85	11	5.5	540	1200	<1	160	160	71
5/30/89	1415	8.0	3830	57	11	0.41	460	1100	<2	150	150	75
7/5/89	1045	7.7	4210	56	3	5.4	430	860	<2	130	130	73
8/1/89	700	7.7	2870	33	7	4.3	280	730	6	150	156	68
9/1/89	830	7.8	3100	39	8	4.6	330	790	<2	180	180	68
9/29/89	715	7.4	3500	52	7	4.8	380	840	<2	160	160	60
MIN		7.3	2870	33	3	0.41	280	730	<1	130	130	46
MED		7.8	3750	59	8	5.2	440	940	<1	160	160	68
MAX		8	5020	123	13	7.3	620	1600	6	180	180	75
COUNT		10	13	13	13	13	13	13	12	12	13	13

Map Index I-8. Charleston Drain at CCID Main Canal (MER502)

Location: Latitude 36°56'59", Longitude 121°46'55". In NE 1/4, SE 1/4, NE 1/4, Sec. 29, T.11S., R.11E.
N side of CCID Main Canal, 8.7 mi. S-SE of Los Banos, 7.9 mi. W-SW of South Dos Palos.

Date	Time	pH	EC µmhos/cm	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk.	Temp. °F
				µg/L							mg/L						
10/4/88	1305		2940	32	1	16	31	31	7	53	2.3	400	770	<1	120	120	68
11/1/88	1330	7.8	3550	44	10	2	5	<5	<5	9	3.0	400	980	<1	150	150	69
12/8/88	1450		5330	81	11	4	12	7	<5	18	5.2	610	1500	<1	140	140	62
1/11/89	1120		5810	99	12	1	7	<5	<5	7	6.0	700	1900			150	52
2/7/89	1140	7.9	4900	53	3	12	24	21	5	34	3.8	640	1400	<1	150	150	49
3/1/89	1310	7.7	4330	87	1	9	26	17	8	33	3.1	550	1100	<1	150	150	60
3/29/89	1320	7.5	5130	125	2	15	29	17	<5	32	4.0	630	1700	<1	160	160	70
5/1/89	1345	7.6	5460	100	5	10	35	16	<5	39	4.6	740	1600	<1	160	160	74
5/30/89	1400	7.6	4400	9.1	3	37	78	60	15	120	3.8	520	1400	<2	150	150	76
7/5/89	1035	7.6	3180	58	1	14	25	29	6	50	2.8	150	890	<2	110	110	69
8/1/89	645	6.8	3760	66	3	19	44	32	6	63	2.8	410	1100	<2	120	120	64
9/1/89	820	7.0	4810	76	8	3	10	7	<5	18	4.3	470	1500	<2	150	150	63
9/29/89	700	7.2	1990	20	4	12	20	19	<5	26	1.6	210	460	<2	120	120	62
MIN		6.8	1990	9.1	1	1	5	7	<5	7	1.6	150	460	<1	110	110	49
MED		7.6	4400	66	3	12	25	17	<5	33	3.8	520	1400	<1	150	150	64
MAX		7.9	5810	125	12	37	78	60	15	120	6.0	740	1900	<2	160	160	76
COUNT		10	13	13	13	13	13	13	13	13	13	13	13	12	12	13	13

Map Index I-9. Almond Drive Drain (MER555)

Location: Latitude 36° 59'55", Longitude 120°49'00". In SW 1/4, SW 1/4, SW 1/4, Sec. 6, T11S., R.11E. N side of Almond Dr., 1.1 mi. E of Mercy Springs Drain, 100 ft. E of CCID Main Canal, 4.7 mi. S of Los Banos.

Date	Time	pH	EC µmhos/cm	Se	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk.	Temp. °F
				µg/L						mg/L						
10/4/88	1250		730	1.3	6	7	8	<5	11	0.16	120	49	<1	92	92	70
11/1/88	1320	7.8	1360	2.0						1.0	170	210	<1	170	170	68
12/8/88	1430		2450	3.7	3	11	6	<5	10	2.6	240	470	7	280	287	58
2/7/89		8.2	2350	4.2	5	15	9	<5	9	2.2	250	470	<1	300	300	58
3/1/89	1255	8.2	2330	3.6						2.2	170	330	<1	280	280	64
3/29/89	1305	7.4	2410	4.4	15	35	30	<5	34	2.4	280	640	<1	270	270	72
5/1/89	1325	7.5	2430	4.8						2.4	300	590	<1	280	280	74
5/30/89	1335	7.5	2160	4.4						2.3	230	480	<2	230	230	74
7/5/89	1015	7.5	1900	3.7						1.8	190	420	14	180	194	72
8/1/89	620	6.7	880	2.5						0.67	91	130	2	120	122	64
9/29/89	640	7.2	640	1.2						0.26	92	59	<2	87	87	67
MIN		6.7	640	1.2						0.16	91	49	<1	87	87	58
MED		7.5	2160	3.7						2.2	190	420	<1	230	230	68
MAX		8.2	2450	4.8						2.6	300	640	14	300	300	74
COUNT		9	11	11						11	11	11	11	11	11	11

Map Index I-10. Rice Drain at Mallard Road (MER509)

Location: Latitude 36°59'22", Longitude 120°14'42". In NE 1/4, NW 1/4, SW 1/4, Sec. 7, T.11S., R.11E.
South South of Santa Fe Grade at Brito, 50 ft. W of Mallard Rd., 4.5 mi. W of Dos Palos.

Date	Time	pH	EC	Se	Mo	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/c	µg/L		mg/L						°F
10/4/88	1440		2900	3.0	16	6.1	320	730	<1	140	140	65
11/1/88	1515	7.8	4150	3.1	19	11	480	1200	<1	190	190	67
1/11/89	1315		3700	2.5	22	7.6	440	1000			270	49
2/7/89	1315	7.8	3050	3.8	15	5.2	350	840	<1	140	140	41
3/1/89	1450	7.8	5480	5.0	32	14	680	1400	<1	230	230	57
3/29/89	1500	7.5	3960	3.2		7.8	440	1300	<1	220	220	72
5/1/89	1515	7.1	2130	4.2	10	4.3	220	62	<1	140	140	75
5/30/89	1520	7.7	2380	2.9	12	5.0	235	615	<2	160	160	75
7/5/89	1230	7.5	2590	2.5	14	5.6	240	610	5	150	150	78
8/1/89	1115	7.8	2110	2.1	8	4.2	200	460	<2	150	150	71
9/1/89	1000	8.0	2180	2.1	7	4.1	240	490	<2	200	200	71
9/29/89	755	7.6	2270	3.9	11	4.3	240	510	<2	160	160	63
MIN		7.1	2110	2.1	7	4.1	200	62	<1	140	140	41
MED		7.7	2750	3.1	14	5.4	280	673	<1	160	160	69
MAX		8.0	5480	5.0	32	14	680	1400	5	230	270	78
COUNT		10	12	12	11	12	12	12	11	11	12	12

Map Index I-11. Boundary Drain at Department of Fish and Game Pump (MER521)

Location: Latitude 37°06'32", Longitude 120°46'45". In NE 1/4, SE 1/4, NE 1/4, Sec. 32, T.9S., R.11E. North of Henry Miller Rd., 4.6 mi. NE of Los Banos.

Date	Time	pH	EC µmhos/cm	Se µg/L	B	Cl	SO4	CO3	HCO3	T.Alk	Temp. °F
					mg/L						
10/4/88	1220		1440	0.6	0.39	240	160	<1	120	120	70
11/1/88	1230	7.5	1430	0.8	0.45	240	160	<1	120	120	65
12/8/88	1350		3820	0.4	1.5	670	560	<1	210	210	56
1/11/89	1040		3170	0.4	1.4	550	460			270	50
2/7/89		7.8	2200	1.1	0.86	340	320	<1	160	160	40
3/1/89	1220	7.6	1870	1.8	0.66	300	260	<1	140	140	55
3/29/89	1210	7.2	2060	1.7	0.74	350	320	<1	150	150	67
5/1/89	1300	7.5	1430	0.4	0.60	230	210	<1	130	130	71
5/30/89	1300	7.7	1310	1.1	0.42	200	160	<2	120	120	74
7/5/89	1420	7.4	1130	1.0	0.37	160	130	2	110	112	81
8/1/89	1220	8.3	950	1.2	0.32	130	98	<2	100	100	74
9/1/89	1050	8.1	1340	0.9	0.45	200	170	<2	130	130	73
MIN		7.2	950	0.4	0.32	130	98	<1	100	100	40
MED		7.6	1440	1.0	0.53	240	190	<1	130	130	69
MAX		8.3	3820	1.8	1.5	670	560	2	210	270	81
COUNT		9	12	12	12	12	12	11	11	12	12

Map Index I-12. Salt Slough Ditch at Hereford Road (MER528)

Location: Latitude 37°08'30", Longitude 120°45'17". In NW 1/4, NE 1/4, NW 1/4,
Sec. 22, T.9S., R.11E. 3.0 mi. N on Hereford Rd. from Henry Miller Rd.

Date	Time	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	CO3 mg/L	HCO3 mg/L	T.Alk mg/L	Temp. °F
10/4/88	1200		1050	1.2	0.25	160	980	<1	130	130	68
11/1/88	1215	7.8	1070	1.0	0.28	170	110	<1	130	130	66
12/8/88	1330		1390	0.9	0.38	180	160	<1	180	180	52
1/11/89	1020		1710	0.4	0.45	250	250			230	44
2/7/89	1015	7.9	1100	1.9	0.37	150	140	<1	130	130	38
3/1/89	1200	7.7	1640	2.3	0.53	260	230	<1	160	160	58
3/29/89	1155	7.4	1220	1.5	0.40	170	180	<1	150	150	66
5/1/89	1235	7.6	1090	1.2	0.36	170	150	<1	160	160	70
5/30/89	1240	7.8	960	1.3	0.38	130	130	<2	130	130	72
7/5/89	1530	7.4	820	1.1	0.30	94	92	<2	120	120	83
8/1/89	1235	8.1	740	1.2	0.25	83	72	<2	110	110	75
9/1/89	1100	8.3	860	0.7	0.30	110	95	<2	120	120	72
9/29/89	840	7.4	830	1.2	0.30	120	78	<2	110	110	66
MIN		7.4	740	0.4	0.25	83	72	<1	110	110	38
MED		7.8	1070	1.2	0.36	160	140	<1	130	130	66
MAX		8.3	1710	2.3	0.53	260	980	<2	180	230	83
COUNT		10	13	13	13	13	13	12	12	13	13

APPENDIX B

Mineral and Trace Element Water Quality Data for Internal Flow Monitoring Stations
Listed in Order by Map Index Number

Map Index	RWQCB Site I.D.	Site Name	Page
T-1	MER510	CCID Main @ Russell Avenue	39
T-7	MER527	San Luis Canal @ HWY 152	40

Map Index T-1. CCID Main Canal at Russell Avenue (MER510)

Location: Latitude 36°55'28", Longitude 120°37'30". In SE 1/4, SE 1/4
SE 1/4, Sec. 33, T.11S., R.12E. 2.7 mi. S of Dos Palos.

Date	Time	pH	EC	Se	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/cm	µg/L	mg/L						°F
10/4/88	1430		790	1.9	0.23	120	66	<1	100	100	65
11/1/88	1500	8.2	820	1.8	0.26	130	79	<1	96	96	67
12/8/88	1630		830	1.7	0.28	130	70	<1	76	76	52
1/11/89	1230		870	2.4	0.31	150	89			84	48
2/7/89	1300	8.1	750	1.7	0.24	110	820	<1	90	90	45
3/1/89	1430	8.4	864	1.8	0.32	140	94	<1	92	92	58
3/29/89	1440	7.7	474	1.3	0.17	59	42	<1	68	68	67
5/1/89	1460	7.8	420	2.0	0.26	39	51	<1	70	70	69
5/30/89	1510	8.1	392	0.7	0.20	41	43	<2	66	66	75
7/5/89	1220	8.0	650	1.9	0.35	72	84	<2	85	85	78
8/1/89	850	8.4	366	1.0	0.15	39	31	<2	62	62	72
9/1/89	950	8.5	579	1.7	0.29	78	66	<2	82	82	72
MIN		7.7	366	0.7	0.15	39	31	<1	62	62	45
MED		8.1	700	1.7	0.26	94	68	<1	82	83	67
MAX		8.5	870	2.4	0.4	150	820	<2	100	100	78
COUNT		9	12	12	12	12	12	11	11	12	12

Map Index T-7. San Luis Canal at HWY 152 (MER527)

Location: Latitude 36°03'03", Longitude 120°48'10".
In SE 1/4, SW 1/4, SE 1/4 Sec. 18, T.10S., R.11E.
N side of HWY 152, 2.5 mi. E of Los Banos.

Date	Time	pH	EC	Se	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/cm	µg/L	mg/L						°F
10/4/88	1455		880	2.3	0.37	120	82	<1	110	110	69
11/1/88	1535	7.8	2470	3.2	2.9	280	550	<1	290	290	68
1/11/89	1340		1210	2.7	0.93	180	180			120	50
2/7/89	1340	8.1	850	1.3	0.37	130	98	<1	96	96	44
3/1/89	1505	8.0	1930	3.3	2.0	240	360	<1	180	180	57
3/29/89	1515	7.7	1400	3.1	1.6	150	290	<1	180	180	75
5/1/89	1535	7.7	630	1.8	0.58	68	100	<1	88	88	71
5/30/89	1540	8.0	620	1.5	0.51	63	89	<2	86	86	74
7/5/89	1355	7.5	1730	2.7	1.9	190	330	6	190	196	77
8/1/89	1140	8.4	1380	2.6	1.5	140	240	15	160	175	70
9/1/89	1015	8.4	590	1.3	0.35	74	70	<2	83	83	72
9/29/89	820	7.9	650	1.2	0.32	94	60	<2	82	82	66
MIN		7.5	590	1.2	0.32	63	60	<1	82	82	44
MED		8.0	1050	2.5	0.76	135	140	<1	110	115	70
MAX		8.4	2470	3.3	2.9	280	550	15	290	290	77
COUNT		10	12	12	12	12	12	11	11	12	12

APPENDIX C

Mineral and Trace Element Water Quality Data for Outflow Monitoring Stations
Listed in Order by Map Index Number

Map Index	RWQCB Site I.D.	Site Name	Page
O-1	MER551	Mud Slough (N) @ Newman Gun Club	43
O-2	MER541	Mud Slough (N) @ Hwy 140	44
O-3	MER554	Los Banos Creek @ Hwy 140	45
O-4	MER531	Salt Slough @ Lander Avenue	46

Map Index O-1. Mud Slough at Newman Land and Cattle Company (MER551)

Location: Latitude 37°18'33", Longitude 120°57'18". In NW 1/4, NW 1/4,
SW 1/4, Sec. 23, T.7S., R.9E., 1.7 mi. NE of Santa Fe Grade, 1.2 mi. N of HWY 140,
4.2 mi. NE of Gustine.

Date	Time	pH	EC	Se	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/cm	µg/L	mg/L						°F
10/4/88	1030	8.0	1830	3.6	1.1	250	280	<1	190	190	64
11/1/88	1040	7.7	2080	2.2	1.3	290	280	<1	240	240	66
12/8/88	1140		1890	1.4	1.2	270	250	<1	240	240	52
1/11/89			2400	0.7	1.6	360	380			310	45
2/7/89			3150	1.5	2.2	440	530	<1	360	360	42
3/1/89	1025	7.8	3280	4.5	2.5	460	550	<1	340	340	56
3/29/89	1015	7.5	3690	5.0	2.8	590	820	<1	360	360	63
5/1/89	1100	7.4	2460	1.6	2.1	380	390	<1	320	320	68
5/30/89	1100	7.1	3040	2.4	2.2	380	650	<2	260	260	72
7/5/89	1700	8.7	1920	2.4	1.3	230	340	16	200	216	86
8/1/89	1620	9.0	1810	2.0	1.4	180	280	8	180	188	83
9/1/89	1240	8.4	2210	1.9	1.8	270	430	<2	220	220	78
MIN		7.1	1810	0.7	1.1	180	250	<1	180	188	42
MED		7.8	2310	2.1	1.7	325	385	<1	240	250	65
MAX		9.0	3690	5.0	2.8	590	820	16	360	360	86
COUNT		9	12	12	12	12	12	11	11	12	12

Map Index O-2. Mud Slough (North) at HWY 140 (MER541)

Location: Latitude 37°17'28", Longitude 120°56'34". In NW 1/4, SE 1/4, SE 1/4, Sec. 26, T.7S., R.9E. 1.7 mi. NE of the Santa Fe Grade HWY 140 intersection.

Date	Time	pH	EC	Se	Mo	Cr	Cu	Pb	Ni	Zn	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/cm	ug/L							mg/L						°F
10/4/88	1105		1350	4.5	4						0.81	180	170	<1	160	160	67
10/11/88	1305	7.5	1350	3.5	4						0.69	200	180			140	70
10/17/88	1635		1260	1.9	5						0.68	170	140	<1	170	170	72
10/25/88		7.3	1450	2.1	6						0.88	180	150	<1	160	160	66
11/1/88	1115	7.5	1990	1.8	9						1.2	300	290	<1	220	220	66
11/10/88	1235	7.6	2490	1.6	11						1.6	340	390	<1	260	260	60
11/15/88	920	7.5	3150	1.6	17						2.0	470	550	<1	280	280	54
11/22/88	1300	7.5	3650	1.9	18						2.4	510	600	7	290	297	55
12/8/88	1215		1790	0.9	6						1.2	240	210	<1	300	300	52
12/28/88	1250		2300	1.1	9						1.5	320	320	<1	280	280	41
1/11/89			2700	0.7	10						1.9	400	430			300	45
1/26/89	1130		3400	2.5	14						2.4	490	580	<1	360	360	49
1/31/89	1050		3300	5.0	13						2.8	490	620	<1	350	350	50
2/7/89			3050	1.1	11						2.2	440	490	<1	330	330	42
2/14/89	1050	8.2	2950	1.1	10						2.2	460	470	<1	340	340	47
3/1/89	1100	7.8	3780	5.0	14						2.8	570	690	<1	350	350	56
3/7/89	1230	7.8	3520	3.7	11						2.6	520	580	<1	360	360	64
3/15/89			3700	2.1	11						2.8	580	640	<1	360	360	59
3/21/89	1125		3630	1.9	12						2.7	590	700	<1	370	370	63
3/29/89	1045	7.6	4090	6.9	18						3.2	610	920	<1	350	350	66
4/5/89	815	6.6	4990	1.9	23						3.3	820	1100	<1	400	400	62
4/12/89	1220	7.3	6350	2.1	31						4.5	1100	1500	<1	420	420	72
4/20/89	920		3200	1.6	8						3.0	490	460	<1	430	430	70
4/26/89	1130	8.1	3160	2.0	7						2.8	480	460	<1	400	400	65
5/1/89	1135	7.6	2810	1.7	7	12	5	<5	13	14	2.5	460	460	<1	350	350	69
5/10/89	1140	7.8	3780	2.3	11						2.8	530	800	<1	260	260	64
5/17/89	1220	8.3	6300	5.0	22						4.8	1200	1600	<1	300	100	76
5/24/89	1150	8.2	6790	8.8	26						5.4	1100	1800	20	280	300	66
5/30/89	1145	8.2	2700	3.0	9	6	3	<5	8	8	2.1	360	370	24	160	184	76
6/7/89	1225	7.8	3470	2.4	11						2.5	500	710	18	200	218	79
6/14/89	950		1930	2.2	13						1.4	250	360	<2	170	170	75
6/21/89	945		4120	2.0	19						2.9	670	1000	<2	240	240	70
6/27/89	1505	8.0	4840	3.3	21						4.4	1000	1600	<2	270	270	
7/5/89	1625	9.0	4950	5.7	19	4	2	<5	8	10	4.1	670	1100	4	160	164	88
7/12/89	1200	8.2	1890	2.0	7						1.5	240	290	11	200		78
7/19/89	1045	8.4	1730	1.9	7						1.4	230	250	<2	220	220	79
7/25/89	900	7.6	1430	4.2	5						1.4	170	210	2	170	172	76
8/1/89	1410	9.0	2050	6.1	7	11	5	<5	12	35	1.9	220	350	6	150	156	79
8/9/89	1200	8.7	3170	7.4	12						3.0	330	630	8	170	178	84
8/16/89	1230	8.2	2760	13	12						3.2	310	590	<2	160	160	81
8/24/89	1425	8.4	2480	11	10						3.1	270	510	3	160	163	78
9/1/89	1205	8.4	3080	9.6	12	8	4	<5	11	10	3.3	410	710	<2	160	160	78
9/6/89	1155	8.3	1100	3.6	4						0.84	130	170	<2	140	140	74
9/13/89	1100	8.3	1630	2.6	5						1.1	230	260	<2	170	170	73
9/21/89	1025	6.8	1220	1.4	5						0.72	150	160	<2	170	170	68
9/29/89	950	7.4	1200	1.6	4	16	4	<5	15	15	0.72	160	150	<2	160	160	65
MIN		6.6	1100	0.7	4	4	2	<5	8	8	0.68	130	140	<1	140	100	41
MED		7.8	3000	2.1	11	10	4	<5	12	12	2.4	425	480	<1	260	260	67
MAX		9.0	6790	13	31	16	5	<5	15	35	5.4	1200	1800	24	430	430	88
COUNT		33	46	46	46	6	6	6	6	6	46	46	46	44	44	45	45

Map Index O-3. Los Banos Creek at HWY 140 (MER554)

Location: Latitude 37° 16'35", Longitude 120°57'14". In NE 1/4, SW 1/4, SW 1/4, Sec. 35, T.7S., R.9E. S side of HWY 140, 2.9 mi. NE of Gustine.

Date	Time	pH	EC µmhos/cm	Se µg/L	B	Cl	SO4	CO3	HCO3	T.Alk	Temp. °F
					mg/L						
10/4/88	1055		910	0.6	0.30	130	69	<1	130	130	63
11/1/88	1105	8.0	1160	1.0	0.43	180	96	<1	170	170	67
12/8/88	1200		2820	0.8	1.2	360	210	<1	590	590	53
1/11/89			1800	0.7	0.91	250	210			310	47
2/7/89			3000	0.8	2.4	410	440	<1	400	400	44
3/1/89	1045	7.8	2080	1.0	1.7	280	260	<1	310	310	57
3/29/89	1040	7.7	7060	0.3	5.7	1100	2500	<1	500	500	62
5/1/89	1125	7.8	1630	1.0	1.3	240	260	<1	250	250	70
5/30/89	1135	8.0	1240	1.3	0.78	120	180	<2	220	220	75
7/5/89	1630	8.5	1250	1.3	0.85	150	160	<2	170	170	89
8/1/89	1430	8.8	1370	0.9	1.0	160	170	2	170	172	82
9/1/89	1210	8.6	1790	2.5	1.4	260	200	<2	250	250	79
9/29/89	955	7.5	800	0.6	0.37	110	69	<2	130	130	66
MIN		7.5	800	0.3	0.30	110	69	<1	130	130	44
MED		8.0	1630	0.9	1.0	240	200	<1	235	250	66
MAX		8.8	7060	2.5	5.7	1100	2500	2	590	590	89
COUNT		9	13	13	13	13	13	12	12	13	13

Map Index O-4. Salt Slough at Lander Avenue (HWY 165) (MER531)

Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4,
Location: Latitude 37°14'55", Longitude 120°51'04". In NW 1/4, SE 1/4,
S of HWY 140.

Date	Time	pH	EC	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	CO3	HCO3	T.Alk	Temp.
			µmhos/cm	ug/L							mg/L						°F
10/4/88	1135		1730	15	5						1.3	240	290	<1	140	140	69
10/11/88	1350	7.8	1400	7.5	5						0.82	200	200			140	69
10/17/88	1600		1270	2.7	3						0.67	180	150	<1	140	140	70
10/25/88		7.4	1500	6.8	4						1.2	180	200	<1	140	140	68
11/1/88	1150	7.7	1620	6.2	5						1.1	230	260	<1	150	150	66
11/10/88	1320	7.6	2130	7.0	8						1.6	310	360	<1	190	190	61
11/15/88	950	8.0	2040	6.7	7						1.5	280	330	<1	180	180	56
11/22/88	1340	7.4	2450	12	8						2.0	330	390	<1	180	180	54
12/8/88	1255		2020	5.4	7						1.6	300	290	<1	170	170	53
12/28/88	1330		2900	13	11						2.7	370	580	<1	230	230	42
1/11/89			2750	15	11						2.8	370	590			200	46
1/26/89	1205		3350	33	14						3.4	430	750	<1	210	210	50
1/31/89	1020		2840	29	9						3.2	360	670	<1	180	180	50
2/7/89	1245		2800	23	10						2.7	350	610	<1	170	170	42
2/14/89	1020	7.8	2420	18	6						2.2	310	520	<1	160	160	48
2/21/89	1230		2850	26	7						2.7	370	580	<1	180	180	60
3/1/89	1130	7.7	3400	38	7						3.9	430	730	<1	190	190	56
3/7/89	1300	7.6	2850	24	7						2.7	390	580	<1	180	180	64
3/15/89			2850	20	9						2.5	400	590	<1	190	190	60
3/21/89	1055		2840	31	8						2.7	400	710	<1	170	170	64
3/29/89	1125	7.3	2000	16	5						1.6	280	450	<1	160	160	65
4/5/89	900	7.2	2900	30	8						2.5	440	690	<1	180	180	64
4/12/89	1130	7.2	2060	17	5						1.8	280	440	<1	150	150	72
4/20/89	955		2270	18	7						2.5	290	490	<1	150	150	70
4/26/89	1100	7.9	2150	18	6						1.9	280	430	<1	150	150	62
5/1/89	1215	7.8	2480	28	8	21	5	<5	15	26	2.7	390	600	<1	150	150	69
5/10/89	1110	7.9	2170	22	7						2.4	270	520	<1	140	140	64
5/17/89	1150	8.0	2180	18	7						2.2	290	460	<1	150	150	73
5/24/89	1120	8.2	1670	14	5						1.6	180	310	<2	140	140	66
5/30/89	1210	8.2	1970	16	6	11	6	<5	10	18	2.2	250	440	<2	140	140	72
6/7/89	1200	7.6	2470	27	6						2.6	320	570	<2	150	150	74
6/14/89	1015		2120	19	6						2.2	240	440	<2	150	150	73
6/21/89	1020		2120	19	7						2.4	260	460	4	150	154	72
6/27/89	1420	6.5	1350	15	7						1.6	210	310	<2	130	130	76
7/5/89	1550	7.6	1860	13	5	10	6	<5	8	10	2.0	220	370	5	130	135	82
7/12/89	1130	7.7	2040	16	5						2.2	230	430	<2	150		75
7/19/89	1125	7.9	1490	10	4						1.5	180	240	<2	130	130	78
7/25/89	1045	7.6	1590	11	5						1.7	170	310	5	130	135	80
8/1/89	1320	7.9	1270	7.4	4	11	7	<5	12	20	1.2	130	220	4	110	114	77
8/9/89	1120	8.4	1670	11	5						1.8	180	370	<2	140	140	80
8/16/89	1210	8.5	1620	9.4	5						1.7	170	280	2	130	132	78
8/24/89	1448	8.2	1530	9.2	5						1.6	170	280	2	130	132	76
9/1/89	1130	8.0	1640	11	5	9	5	<5	12	17	1.6	190	310	<2	140	140	73
9/6/89	1125	8.5	1570	10	5						1.5	190	290	<2	140	140	72
9/13/89	1135	7.8	1540	12	5						1.4	210	270	<2	130	130	72
9/21/89	1050	7.3	1740	14	6						1.6	200	300	<2	140	140	68
9/29/89	910	7.4	1830	18	5	19	6	<5	14	24	1.7	230	340	<2	140	140	67
MIN		6.5	1270	2.7	3	9	5	0	8	10	0.67	130	150	<1	110	114	42
MED		7.8	2040	15	6	13	6	1	12	18	1.9	270	430	<1	150	150	68
MAX		8.5	3400	38	14	21	7	0	15	26	3.9	440	750	5	230	230	82
COUNT		33	47	47	47	6	6	6	6	6	47	47	47	45	45	46	47

Figure 2

Grassland Area of Western Merced County

MONITORING SITES